Power and The Engineer

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WHEN a man is advanced from a subordinate position to one of trust and responsibility within a comparatively short time, public opinion usually attributes his success to either favoritism or luck without stopping to consider that perhaps he possesses special qualifications for the position.

Favoritism, although occasionally found in certain classes of service, is seldom practised in strictly commercial or engineering circles. Too much risk is involved in putting an incompetent man at the helm. Hence, with rare exceptions, the responsible position goes to the man who can produce the "goods."

It cannot be denied that the element of chance figures, to a certain degree, in shaping the careers of most people, yet it does not play so important a part as is generally supposed.

Those people who are born under a lucky star are nearly as scarce as hen's teeth.

At some time or another opportunity knocks at everyone's door, and indeed to many it is a frequent visitor, but whether it is taken advantage of depends entirely upon the individual concerned.

One of the surest ways to achieve success is to be prepared to sieze an opportunity when it is presented. It is too late to prepare after the opportunity has appeared, for in that case the chances are that another will get the job.

There are people who consider that if they do their daily routine work in a satisfactory manner, they are performing their duty. They may be doing their duty to their employers, but not to themselves. Time spent in picking up additional information pertinent to their work is not wasted, but is really invested at a high rate of interest.

An incident exemplifying this occurred some time ago at a large manufacturing plant in New England. One of the employees who held a subordinate position spent his spare time in picking up bits of information regarding the operation of departments other than that in which he was employed. He also became interested in electricity and when the plant finally changed over to electric drive, a slight accident gave him an opportunity to be of service. This brought him to the attention of those higher up and he was given a better position which afforded him further opportunity to become familiar with the operation of the plant.

His real opportunity came when the superintendent was suddenly stricken with paralysis. The general knowledge he had gained proved so useful at this time that a large part of the superintendent's duties fell to his lot. This gave him the chance he had been waiting for, and he immediately introduced a number of changes which decreased the cost of production. When the superintendent was permanently incapacitated for work by a second stroke, our friend was immediately chosen to fill his place.

All this happened within a little over three years, and although it is only one of many such instances, it serves to emphasize the fact that one should be always ready to meet the unexpected.

Repair of a Large Engine Bed

By F. W. Brady and C. J. Mason

Due to culm being carried over with the circulating water into the low-pressure cylinder, the guide barrel was split off from the rest of the frame. The repair was effected by cutting out the guide barrel and the attached portion of engine bed, and inserting a new section.

Some time ago in an issue of POWER there was given a short account of an unusual engine wreck. The engine was a cross-compound of 2400 horsepower, driving a direct-connected street-railway generator, and the wreck was caused by coal being carried into the low-pressure cylinder by the cooling water of the barometric condenser. The water was raised by a centrifugal pump from a nearby river, the banks of which were lined by numerous culm piles, and each freshet carried quantities of the culm down stream. On this particular occasion the tail pipe of the condenser became clogged with culm; then the overflow, as the centrifugal pump continued operating, came over into the engine-exhaust pipe. The vacuum was lost and the dry-air pump, becoming choked with the culm, was stalled. It all happened so suddenly that those on watch had no idea as to what was taking place. However, tney immediately proceeded to shut down the engine, and while so doing, the suction of the low-pressure piston drew a charge of water and culm into the cylinder. On the return stroke the piston struck the imprisoned mass, and the turning force of the flywheel and generator armature knocked the cylinder base from the bed. Fortunately, the cylinder itself escaped injury, but the 18-inch connecting piece between the cylinder and the bed was broken. This let the crank end of the cylinder drop, as it had no other support, resulting in a broken steam connection and a wrecked valve gear; the head end of the cylinder resting on two flanged feet clamped to the foundation capstone.

The most serious break, however, was that of the guide barrel, which had the top split off by the upward pressure of the connecting rod against the crosshead, which, in turn, bent the piston rod as well as the end of the connecting rod itself. The 3⅛-inch key in the crank disk was also partly sheared off.

The engine bed included the guide barrel in one solid casting 20 feet long; hence the breaking of the guide barrel made it necessary to procure a new bed. As it was specially desirable to continue the operation of the high-pressure side of the engine, and as this required the use of the pillow block of the main shaft on the broken bed, and also as a method of reducing the cost of making the repair, it was decided to cut out the 9-foot guide-barrel section.

The cylinder was stripped and blocked as shown in Fig. 1, so that the work on the bed could be done as conveniently

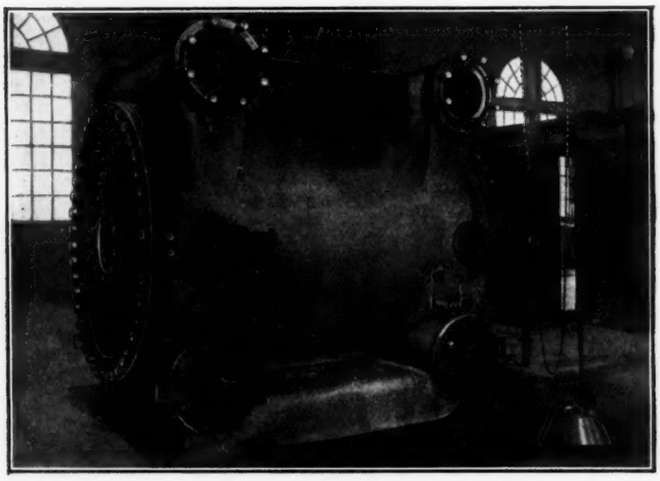


FIG. 1. CYLINDER STRIPPED AND BLOCKED

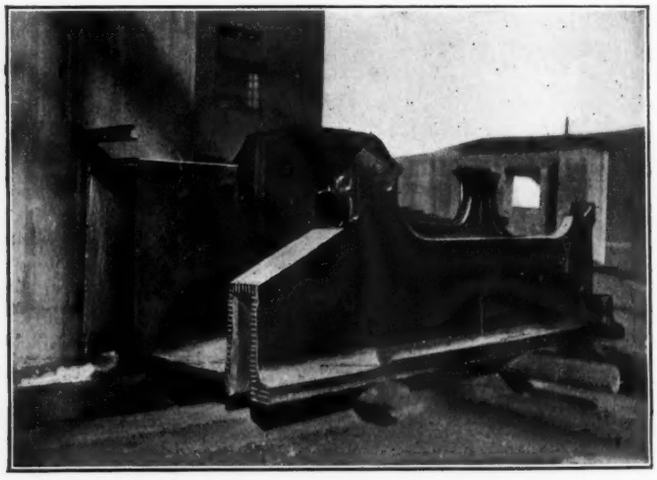


FIG. 2. BROKEN GUIDE BARREL CUT FROM BED

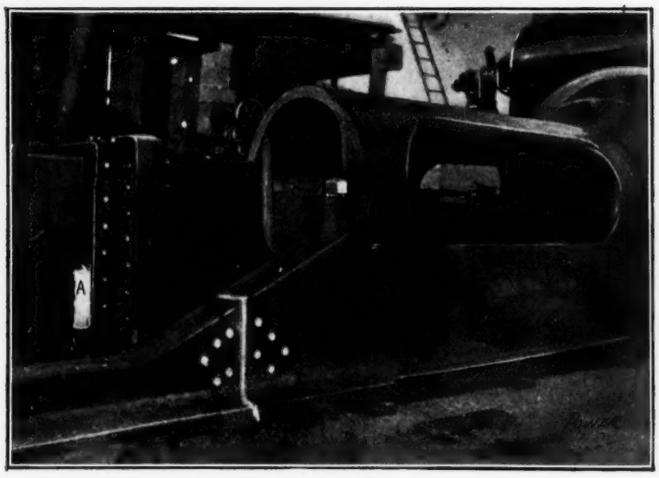


FIG. 3. NEW GUIDE BARREL IN PLACE

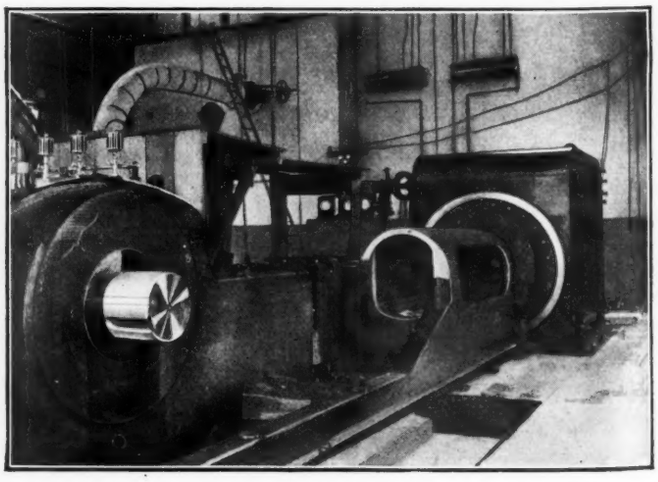


FIG. 4. ENGINE BEFORE RECEIVING NEW CRANK DISK

as possible. The 9-foot section, shown in Fig. 2, was then cut from the bed by drilling ¾-inch holes along the entire cutting line. It will be seen from the illustration that the bed where cut consists of two box sections connected at the bottom by a horizontal flange. The rear box is 40 inches high and 20 inches wide, the connecting flange 28 inches wide, and the front box about 10 inches wide and 20 inches high. The thickness of the metal ranges from 1⅜ to 1¾ inches and the weight of the section cut out was a little over four tons.

After removing the damaged section the concrete foundation was cut down two or three inches to give clearance. Pits were chiseled under the joints (one is shown in Fig. 4) and extended out into the floor so that the workmen could get under the bed. Fig. 3 shows the new piece set in place together with some details of the joint. The new guide-barrel casting is made with a 3-inch flange on both the rear box section and the bottom web. A similar flange having a 7-inch plate was clamped to the end of the pedestal casting by means of a double row of 1½-inch square-headed screw bolts and the two castings were held together by a single row of hexagon-headed screw bolts. Lead was run into the crevice between the bed and the plate on the flange, the dam at *A* being for that purpose.

The low portion of the box section at the front of the bed was fastened to the guide barrel by means of plates placed on the inside and held by screw bolts, five bolts being used through each end. A fitting strip, or liner *B*, about ⅞ inch thick, was used to close the space between the abutting surfaces. The screw bolts and liner were then dressed flush with the outer surface so that the bed might have a smooth surface finish when painted.

A housing of rough boards was erected over the foundation to protect the generator from the dust, etc., incident to the repair of the bed. A new crank disk was also necessary, for the original one had one-fourth of its circumference broken off and the 3⅛-inch key was sheared over about half way. The disk, which was 63 inches in diameter, was removed from the shaft by drilling a row of five holes and driving tapered pins into them until the disk opened up enough to permit its being taken off. The 10x10-inch crank pin was not injured at all.

About five months elapsed from the date of the accident until the engine was again put into service. To prevent a possible repetition of the accident a change in the condensing-water supply, so as to filter the water and remove all foreign material, was necessary.

A New Theory of Belt Driving*

By Selby Harr

Conclusions drawn from the results of over 1000 *tests conducted by Professor Kammerer, of Charlottenburg, Germany.*

The effective pull on a belt is not reduced so much by centrifugal force as the currently accepted method of calculation would lead one to expect. In other words, the maximum allowable tension in a belt apparently increases with the speed.

The coefficient of friction increases with the speed and reaches values far above that usually assumed.

The maximum efficiency of transmission is not limited by the speed.

The coefficient of friction is larger for large pulleys than for smaller ones.

A wooden pulley has a higher coefficient of friction than an iron one, at least when new.

Transmission is more efficient and the coefficient of friction is higher when the smaller pulley drives.

A belt operates with higher efficiency and usually with less creep when the tight side is on the bottom.

A properly placed idler improves the efficiency of transmission.

The neutral layer is symmetrically located in the belt so that the effective diameter is the sum of the pulley diameter and the thickness of the belt.

At any speed the sum of the initial tension and the centrifugal force is constant.

In concluding his paper, Mr. Haar made the following statement:

As a result of the modern experimental work on power transmission by leather belting, a great deal of light has been shed on the subject and the methods of treating it must be revised. It appears evident that the maximum allowable tension in a belt is not constant and neither is the belt velocity, even though the pulleys revolve at constant speed. The efficiency of a belt is shown to be quite high, just as high as a good gear transmission, the over-all efficiency of the belt transmission being considerably reduced by larger bearing friction losses. This shows that the improvements should come in the bearings, as by the use of ball or roller bearings, for example. The exceptional flexibility of a belt transmission has made it a favorite for many difficult problems. We shall close with the following remarkable—and, we are afraid, overenthusiastic—prophecy of Mr. Gehrckens:

Sixty meters per second (11,900 feet per minute) is no limit to belt speeds at present. Belt pulleys have run at 500 meters per second (98,000 feet per minute). Brown, Boveri & Co. have reached 375 meters per second (74,000 feet per minute); the Schuckert Company run flywheels at 100 meters per second (19,600 feet per minute) (and so do American manufacturers).* Air resistance is an important feature at such speeds. When air is excluded the resistance decreases to one-half, and in a vacuum it is almost nothing. * * * We are by no means close to the limit of belt speeds, and the capacity of the belt does not commence to increase until high speeds are reached. Steam-turbine speeds are so high that some reducing device must be provided and for this purpose the belt is the simplest and most practical connecting link. With transmissions at such high speeds the construction must be painstaking and the crowning of the pulley is an important feature.

The discussion following the presentation of the paper was in brief, as follows:

C. G. Barth: I am pleased to see that Mr. Haar takes the view that we cannot hope to run belts at the tremendous velocities used in Germany. At high speeds the initial tensions would be so high as to overbalance the centrifugal forces so that high tensions could not be maintained very long.

G. M. Vanderhoff: The best belt drives are those which represent the wisest investment; therefore, all the factors entering into the investment must be considered. The narrowest belts consistent with the other factors means maximum economy. A mean between the high speed demonstrated in the German research and the moderate speeds suggested by American engineers would represent the best practice.

In designing belt drives it seems that some of the things to be kept in mind, in view of the papers presented, are: first, decreasing the slack-side tension by in-

*Abstract of paper and discussion presented before the American Society of Mechanical Engineers' annual meeting, New York City.

*Parenthetical expression is Mr. Haar's own comment.

creasing the arc of contact; second, increasing the coefficient of friction. The arc of contact can often be increased to advantage by the use of large-diameter idlers. A high coefficient of friction can be obtained by the use of wooden pulleys. The statement that belts do not last as long on wooden pulleys as on iron pulleys does not apply to wooden pulleys with iron faces.

It would seem from this paper that the ratio between the diameter of pulley and thickness of belt should be, for the best results, considerably greater than we have been inclined to think sufficient.

Harrington Emerson: In some respects I cannot help but differ from Mr. Haar's paper. There are two or three main facts about belts; one is that if there is a large initial stretch, owing to a high tension, much power will be lost. If the belt is stretched 15 per cent. the driving pulley will travel that much faster than the other. Also, if there is a high tension there will be a large arc of slip; and this wears out the belt.

The only legitimate wear of a belt is what occurs in the slip; except for that, a belt should last forty years.

Mr. Taylor: When anybody suggests a speed of 11,900 feet per minute for a belt, he is very near the limit. Experimental data which are the result of purely academic experiments, made on a machine especially made for the purpose, should not be followed blindly, unless backed up by experience. Five to six thousand feet per minute is a ruinous speed for belts and economy. It should neved be practised unless necessary, and ordinarily should not exceed four to five thousand feet per minute.

G. I. Rockwood: Mr. Taylor's remarks apply to small belts but when a belt is transmitting power from a 5000-horsepower engine it is different. For such practice 5000 feet per minute has been in use for years.

Burning No. 3 Buckwheat Coal

By Warren O. Rogers

This grade of coal can only be used when forced draft and shaking grates having small air spaces are employed. The fire must be handled in a certain way as all ordinary methods result in failure. The method used by one of the largest steam generating companies in the world may be of interest.

Burning their coal for them is what the New York Steam Company is doing for over thirteen hundred customers. In other words, this company, which is said to be the largest of its kind in the world, sells the product of its boilers direct to its customers unmodified by any question of engine and generator conversion.

In order to supply the demand for steam, three large steam-generating plants are maintained, two at the foot of East Fifty-ninth street, and one at 173 Washington street, New York City. The smaller uptown boiler house contains

FIG. 1. THE FIREMAN AND HIS TOOLS

eight 650-horsepower Babcock & Wilcox boilers, a total of 5200 horsepower. The larger uptown plant contains 24 boilers with a capacity of 11,410 horsepower, or a total of 16,610 boiler horsepower for both plants. These boilers consist of three 270-horsepower Babcock & Wilcox, seven 1000- and two 750-horsepower Climax boilers and four 525-horsepower Aultman-Taylor boilers. The downtown plant contains fifty-six 250-horsepower Babcock & Wilcox boilers, eight 350-horsepower boilers of the same type, one 350-horsepower Parker down-draft boiler and one 1000-horsepower Climax boiler, a total of 18,150 boiler horsepower.

These boilers are mostly equipped with a grate designed by G. C. St. John, president of the company. They are of the shaking type and have a 47 per cent. air space. Fig. 4 shows the design. Forced draft is used under all boilers in the three plants with one exception, which boiler is run under natural draft.

No. 3 buckwheat coal is burned with an average draft of from 0.5 to 0.6 inch of water. No damper regulators are used on any of the boilers, the damper being manipulated by hand and kept from ¼ to $\frac{5}{16}$ open.

Eleven to 12 pounds of coal are burned per square foot of grate surface. One fireman attends to three of the 250-horsepower boilers; two of the 650-horsepower boilers are fired by one man and one Climax boiler by two men. The fires are carried at a thickness of from 3 to 12 inches, depending upon the length of time the fires have been run without cleaning, which duty is performed twice during each eight-hour shift. The fires are all carried at the same thickness, are kept level and the work of firing is practically a continuous performance.

During my visit to these boiler plants the following procedure was observed: The fireman opened a furnace door and at a glance noted the condition of the fires. The scoop shovel was then deftly handled, green fuel being thrown on the places where incandescent coal showed. The red spots in the fuel beds were not covered.

"Now watch that man," said the chief engineer of the plant, and I did. The shovel was thrust into the coal pile in front of the boiler, and, with a skill that was surprising, one-half of the amount picked up was distributed around one side of a red place, and, with a twist of the wrist and more skill, the remaining coal was distributed around the other side of the red coal. Wherever a red place showed, no coal was thrown. In this way the fuel was allowed to become incandescent and not permitted to work down into the ashes and finally be dumped into the ashpit to be carted away as refuse.

At intervals of about two hours a light hoe was used to level the fire and mix

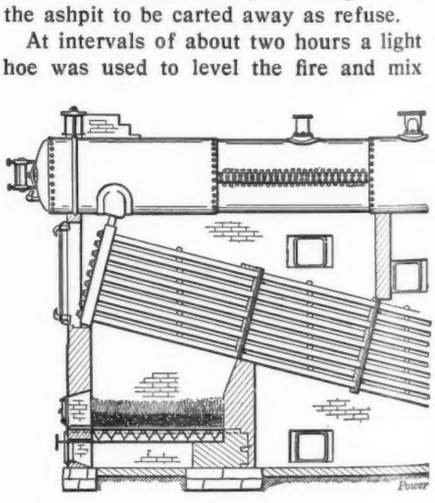


FIG. 2. PROPER CONDITION OF FIRE

such green coal as had failed to properly ignite, with the burning fuel. Fig. 1 shows all the tools that it is necessary to use in the boiler room.

"How are the fires cleaned?" I asked.

"Come down stairs," answered the chief. (The boilers of the downtown plant occupied four floors.) We went down to a lower floor where the men were busy cleaning fires, two at a time.

The beds of ashes and red-hot clinkers and coal were about 10 inches thick, but the proportion of coal was small. The fireman operated the shaking grates, until there was but 1 inch of ashes left on

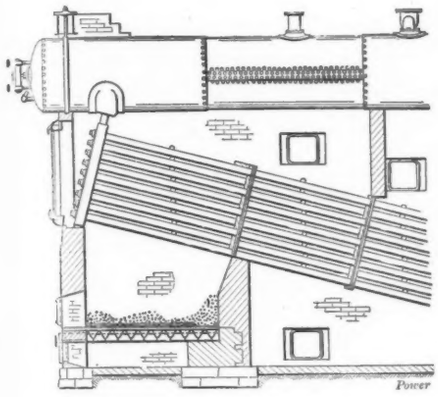


FIG. 3. BADLY KEPT FIRE

the grates. These were then smoothed off level with a light hoe, and about ½ inch of green fuel thrown on this bed. The furnace doors were closed and the forced draft turned on.

"I guess he has lost that fire," I remarked, as the fireman finished, for there was no sign of live coals after the green fuel had been thrown into the furnace, nothing but the glow of red-hot sides and bridgewall.

"In five minutes that furnace will have as pretty a fire as you want to see," replied the chief. As he spoke he opened the furnace door and sure enough little shafts of blue flame were seen shooting up through the black bed of coal. In about five minutes we returned to the boiler and, as predicted, the furnace contained a bright, hot, even fire.

"How will the fireman handle that fire for the next two hours or so?" I inquired.

"Watch him," was the reply.

I did so. The fireman took the shovel and, to me, accomplished but half a job. Instead of covering the entire surface of the burning coal with green fuel he scattered a little over the bright places in the rear next to the bridgewall, firing heaviest at the front, but heavy does not mean more than ½ inch thick.

"Why doesn't he spread the same thickness of coal over the entire grate surface?" I asked, while the inclination was strong to take the shovel and complete the work of properly (?) firing the boiler.

"It would be useless work," was the reply; "besides it would be a waste of coal. Owing to the pitch of the grates, the influence of the draft and the occasional leveling of the fires, the fuel works itself back to the rear of the furnace." Figs. 2 and 3 show proper and inproper conditions of the furnace.

"What kind of a slice bar is used?" was my next question, not noting any lying about.

"None is ever used; there isn't one in the plant," was the reply. "Couldn't find a quicker way of killing a fire or of wasting coal than by using one."

"Do you test your coal?" I next asked.

"Yes, a sample from each cargo is taken. For instance, about four cargoes are received each week. When the coal arrives one boiler is put on test and run for eight hours, a record being kept of the coal burned, the water evaporated and the ash content of the coal. More than that, the coal is graded; that is, 100 pounds of coal is taken from each cargo and sifted to determine the grades of coal contained in it. This sample is passed through screens, the first having a 3/16-inch mesh, which allows everything but No. 1 buckwheat to pass through to the second screen, which is of ⅛-inch mesh. This screen retains the No. 2 grade. The third screen has a mesh of 3/32 inch, which retains the No. 3 buckwheat coal, and all that passes through the screen is classed as No. 4 grade, which is practically dirt.

"Looks easy enough to burn barley coal," I remarked, as I made ready to depart, expecting an out and out denial.

"It is —— when you know how," replied the chief. "You have seen the whole process, and that is all there is to it. It comes hard on a new man, because he wants to throw a lot of coal up against the bridgewall, the same as you wanted to, and he wants to fire heavy and above all stir the fire. We do just the opposite here, and that is why we get good results in the three boiler plants."

As I went away I summed up the situation in burning No. 3 buckwheat as follows:

Fire light and often.

Keep a forced draft of from 0.5 to 0.6 inch.

Keep the damper 5/16 open.

Never use a slice bar.

Level the fires about every two hours, or when necessary.

Never throw green fuel on other than incandescent fuel.

When cleaning fires keep one inch of ashes on the grates.

Always use a shaking grate.

Never handle the fire as other fuels are handled.

After noting the methods used in burning No. 3 buckwheat coal it would appear that a small steam plant containing one or two boilers would have trouble in running on this grade of fuel, because it would be difficult to force the fires in case a sudden demand was made for steam, and doubtless it would be hard to keep up steam when cleaning fires if the boilers were hard pressed.

The foregoing information was obtained through the courtesy of Fred A. Rankins, chief engineer of the downtown plant, and John Felder, chief engineer of the two uptown stations.

Pete Blowoff got drunk agin tother day an' when an' old mule kum 'round his ingin room an' begin t' brayin', Pete sed he gessed th' dumd masheen needed ile frum th' way it skreaked, so he went out an' pored 'bout a gallon uv ile in th' critter's ear; then he got 'round behind it an' got t' pumpin' its tail, thinkin' it wuz th' startin' bar uv his ingin; he started sumthin' all right, th' gol darnd critter landed on th' bib uv his overalls with both feet an' th' fust thing Pete sed when he'd kum to wuz t' ask ef th' 'sploshun wuz caused by low water. Th' docter told 'im thet it wuz caused by a combinashun uv low booze an' a couple uv jackasses.

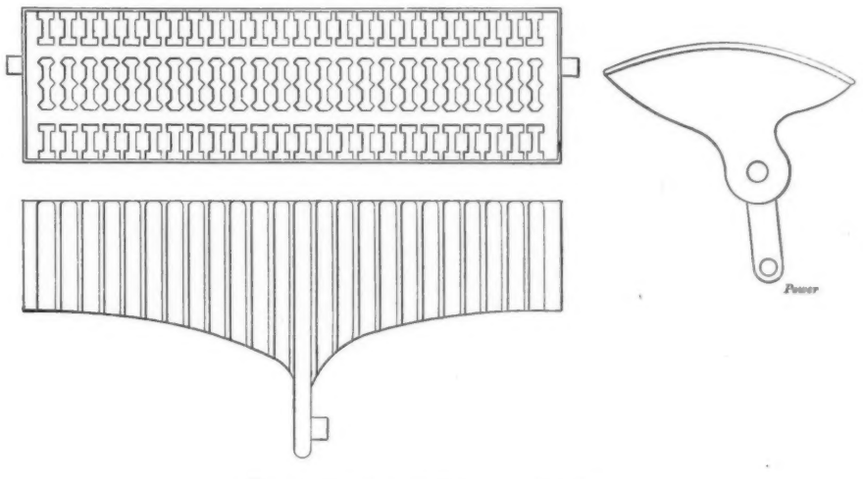


FIG. 4. DESIGN OF SHAKING GRATE

The diameter in quarter-inches squared and divided by six equals the approximate weight, in pounds per foot, of a bar of iron.

Testing a Planimeter for Accuracy

By W. L. Durand

To determine the accuracy of a planimeter the user must ascertain whether the readings are uniform, whether the length of the tracing arm is accurate and whether the axis of the recording wheel is parallel. An outline of each test is presented.

The planimeter is one of the most widely used of the measurement instruments employed by engineers, yet few understand the principles on which the planimeter is based or the methods employed to determine if a particular instrument in use is giving correct results.

The following are three tests that should be applied to all planimeters before complete reliance is placed on the readings they give:

Test for uniformity in the record-wheel readings.

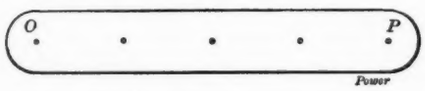


FIG. 1. THE CHECK RULE

Test for accuracy in the length of the tracing arm.

Test for parallelism of the recording-wheel axis.

To test for uniformity in the record-wheel readings a small check rule, as shown in Fig. 1, should be made of a thin strip of some metal such as brass. The rule is pivoted at *O* and the point of the planimeter is placed at one of the points on the rule, as shown in Fig. 2, and an area traced. Ten readings should be taken in this way, and then the tracings should be repeated in a negative direction, which should give the same readings as those in the positive direction. If the difference between the maximum and minimum result does not exceed 2 to 2.5 units of the vernier the planimeter may be considered to be correct in this respect. The errors are most apparent when the circle traced nearly coincides for some distance with the zero or base circle.

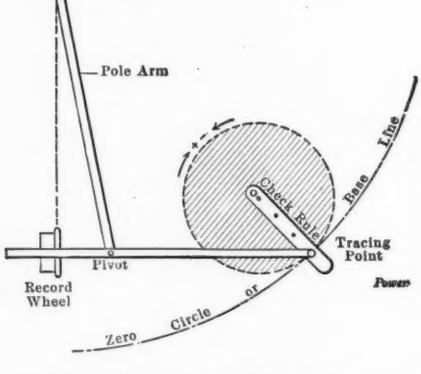


FIG. 2. TEST FOR UNIFORMITY IN RECORD-WHEEL READINGS

The zero circle is a circle around the pole point of the planimeter as its center and made by the tracing point so that the graduated wheel is continually traveling in the direction of its axis and consequently will not revolve. To find the zero circle, first a circle larger than the zero circle and then one smaller are drawn. The reading given by the planimeter for the larger circle is the area of the strip between the zero circle and the outer circle, while the area recorded for the small circle is the area between that circle and the zero circle. The area of the zero circle is equal to the true area of the small circle plus the strip between the small circle and the zero circle or to the true area of the large circle less the strip between the large circle and the zero circle. Hence, the area of the zero circle is equal to the true area of the small circle plus the recorded area of the small circle or to the true area of the larger circle less the recorded area of the large circle.

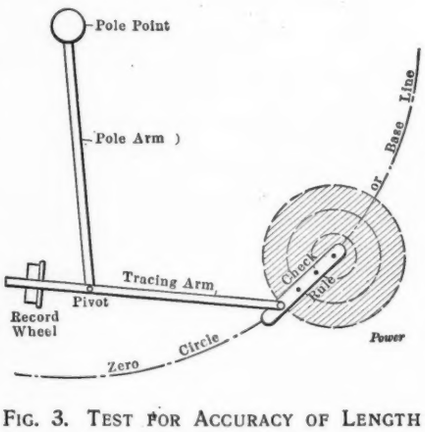


FIG. 3. TEST FOR ACCURACY OF LENGTH OF TRACING ARM

To obtain the best readings with any planimeter the zero circle should always be found and the area to be measured placed so that the circumference of zero circle runs through it, and the point of origin should be chosen on the zero circle so that a slight failure in returning to the origin will not be recorded by the wheel.

To test for the accuracy of the length of the tracing arm, trace by means of the check rule several circles of known areas a number of times, as shown in Fig. 3. Compare the mean of the results with the known area. If the results are too small by $\frac{1}{n}$th of the area the length of the tracing arm must be shortened $\frac{1}{n}$th of its length and *vice versa.*

To test for parallelism of the record-wheel axis use the check rule, as shown in Fig. 4, and make a series of tracings of a circle outside the zero circle and another series of a circle inside the zero circle, keeping the circles as far from the zero-circle circumference as possible. If the readings outside and inside are equal the axis is parallel, but if the area recorded outside is the larger the end of the axis nearest to the tracing point must be moved toward the outside and *vice versa.*

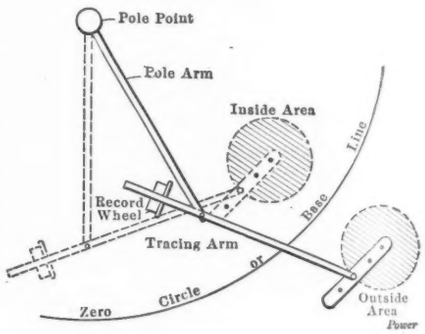


FIG. 4. TEST FOR PARALLELISM

According to the British Consul at Stockholm, the total water power in Sweden is estimated at approximately 10,000,000 horsepower, available during from six to nine months of the year, and 2,500,000 horsepower available during the time of low water. In the near future 600,000 horsepower will be in use, including 340,000 horsepower for the generation of electrical energy. At the present time the state possesses, or is part proprietor of, waterfalls of about 880,000 horsepower, of which 670,000 horsepower could be used without previous regulation of the respective waterfalls. Only 63,000 horsepower is now in use by the state, including some 40,000 horsepower at the power station at the Trollhattan falls. Work is now in progress at Trollhattan by which a further 40,000 horsepower may be used there. At the Porjus fall on the Lulea river in Lapland, a power station is to be erected with a capacity of 50,000 horsepower. In addition, the Swedish government proposes to set up works at Alfkarleby, in Upsala lan, Uppland, and other places.

Estimating Heating Requirements*

By Reginald P. Bolton

The usual method of estimating the amount of heating required for a given building, based on the areas of exterior surfaces and their relative heat transmitting values, with an additional allowance for cubical contents, is considered to be inexact because it does not take accurately into account loss due to infiltration. A method which does include this factor is presented and discussed.

The common method of relating the work or cost of heating to the cubic contents of a building, is one which is liable to be misleading, and may lead to over or under estimation from causes that will be evident. The actual work of heating is not varied by the fact that the interior of the building is of a certain size, but it is directly varied by the exposure of the exterior of the building to outside temperatures and to wind effects.

The usual methods of computation applied to new buildings are based upon the ascertainment of exterior surfaces and their relative heat-transmitting values, with an addition thereto of a certain fixed allowance for cubical contents, on the ground that these contents represent approximately the amount of air leaking into the building from the exterior in one hour—giving for one change of contents per hour:

$$\left(\frac{W}{4}+G+\frac{C}{55}\right)t = \textit{heat losses in units}$$

where,

W = Wall surface exposed;
G = Glass surface exposed;
C = Cubic contents of interior space to be heated;
t = Temperature difference between exterior and interior.

While the losses of heat from the exterior of a building are by this method fairly ascertainable, the loss by infiltration is empirical, and this item becomes of considerably increased importance as buildings are increased in hight. Methods of building construction, while they have been largely improved in a general way, have not relatively been improved in the matter of the construction and setting of window frames, and in high and unprotected buildings the loss of heat due to this cause is quite a substantial element in computations of this nature. The increase of wind velocity and corresponding pressure due to hight is shown in Fig. 1, from which it will be seen that any opening or leakage point situated at a considerable hight above the ground must be regarded as of greater extent or capacity for leakage than one which is below the average level of buildings in the immediate neighborhood.

Another element which contributes to this result is the funnel or chimney effect of tall buildings, which establishes, under certain conditions of wind, a strong draft through the corridors and elevator shafts, thereby drawing away heat from the lower portion of the building. On account of this effect it has been found necessary in certain tall buildings to add heating surface to the lower floors, in excess of computed requirements.

The following theoretical method, which has been followed by the writer, of ascertaining the heating work for any building has given very close approximations to actual results.

An examination of the recorded variations of temperature for thirty years past has afforded the means of plotting the average hourly variations for each month of the heating season, bringing out the fact that the night temperatures are generally lower than the day temperatures, and that the work required for heating is always relatively lower at the period of maximum day work.

The diagram in Fig. 2 is used for the ascertainment of these average hourly conditions, the temperature curves being inverted and becoming a relative scale of boiler horsepower, so that the average proportion of heating required at any particular part of the day in any month of the season can be rapidly ascertained. These curves are based upon the recorded conditions of the heating season of 1903-4, which were found to

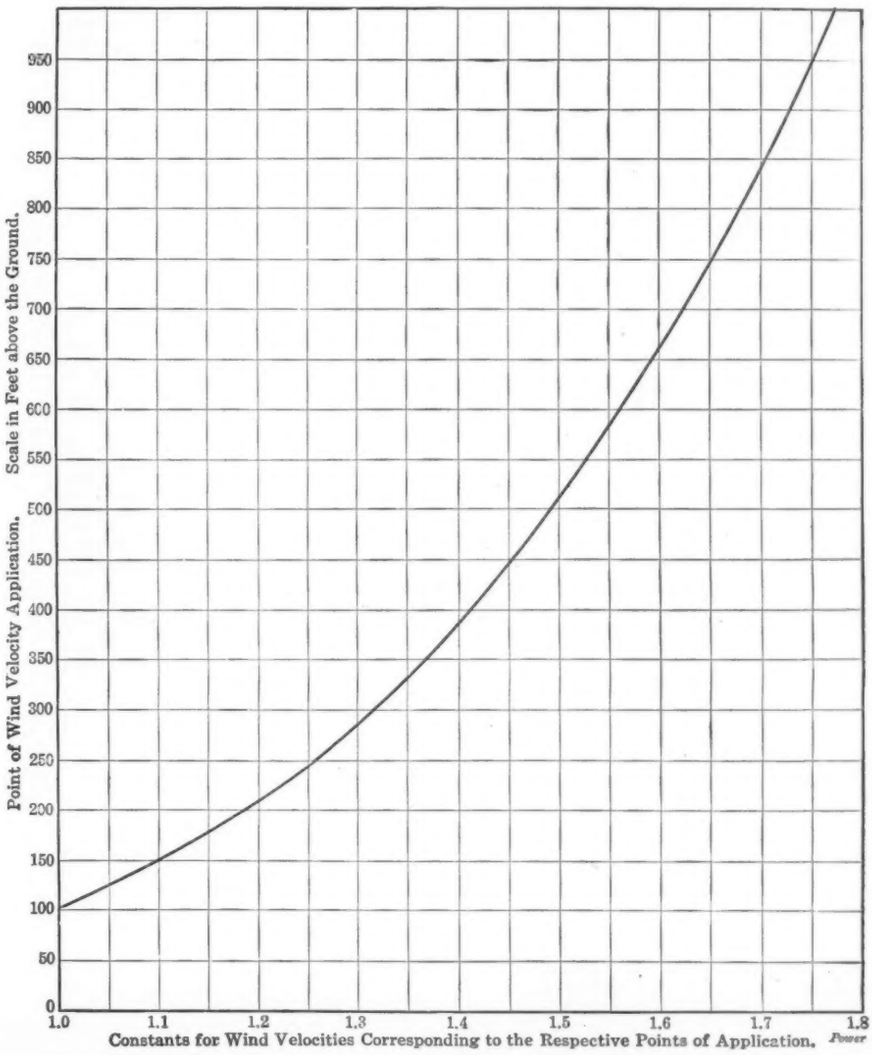


FIG. 1. INCREASE IN EFFECT OF WIND VELOCITY DUE TO HIGHT

*Excerpt from "The Heating Problem in Its Relation to Central Station Lighting and Power Service," a paper read at the annual meeting of the Association of Edison Illuminating Companies."

be very close to the general average for thirty years prior to the year 1907.

It will be seen that the maximum observed heating work, which is that at the top of the diagram, on the rare occurrence of a zero temperature, falls off after the day hours, and, as has been already noted, on only about eight days of the heating season, or less than 4 per cent. of the heating period is there any temperature approaching the neighborhood of zero Fahrenheit.

In times gone by, a temperature of zero was more frequently recorded, and as it is frequently reached in the vicinity of New York City, it seems probable that the general temperature of the borough of Manhattan has been raised by the heat emitted from the numerous heating plants in the closely built-up center of the city.

The effect of wind in increasing the results of low temperature has been made the subject of separate study. Close observation has been made of the variations of wind during the heating season, derived from the invaluable hourly records maintained for many years past by the Meteorological Bureau of the Department of Parks of the Borough of Manhattan, under the care of Dr. Daniel Draper. Combinations of high velocity and low temperature have been searched for over the records of many years and the most severe heating combination found has been that of a wind velocity of 42 feet per second accompanied by a temperature of 20 degrees above zero, which combination occurred on January 1, 1904, and would represent for an exposed and lofty building a condition somewhat in excess of zero temperature in a still atmosphere. The combination is, therefore, adopted of a zero temperature with this wind speed in order to arrive at the suitable amount of heating surface on exposed windowed sides of any building.

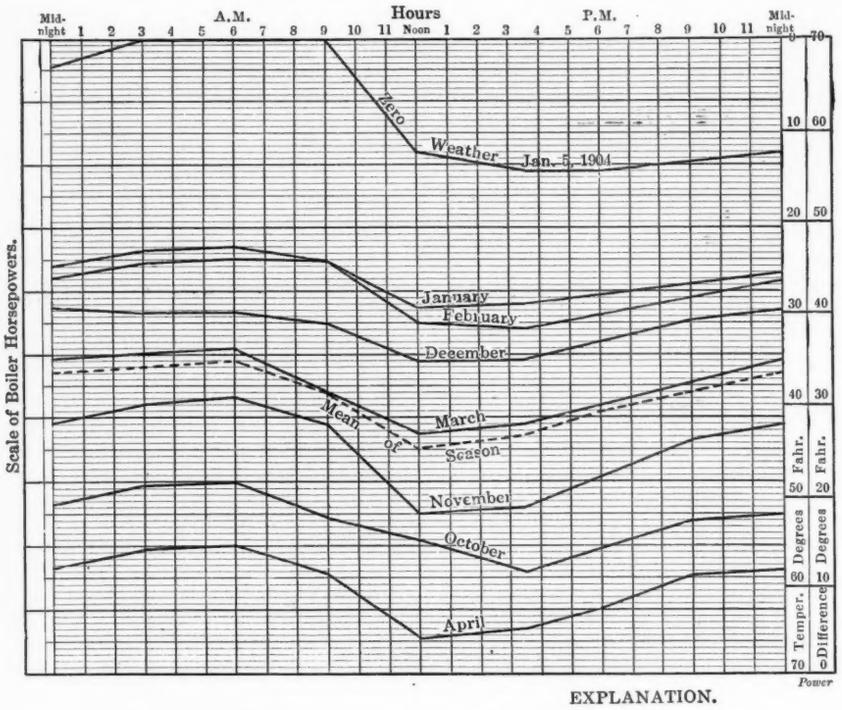
The average wind movement for a month may then be utilized with effect in a computation of heating work, notwithstanding the variations of movement and direction, and the system of proportioning heating surface to meet wind effect from any point of the compass eliminates dependence upon common methods of adding empirical amounts, such as 10 to 35 per cent., to heating surfaces on the north or other side of a building.

The effect of wind is mainly found to be in the leakage of cold air around the window framing, sashes and meeting rails, an effect increasing with hight from the surface or general level of other protecting structures. The use of close metallic weather stripping to reduce leakage around window sashes has been the subject of much discussion, and of some investigation, and in the recent experiments of H. W. Whitten, the writer had the interest of taking some part. By mounting a small room on a pivot upon the roof of the West Street building, the opening in which room was alternately provided with various forms of window construction, it was possible to test the amount of air passing through the sash at various speeds and pressures of wind. The general result of this and other investigations on the subject is to indicate that the excellence or poverty of construction of window frame and sashes may affect the total heating work to be done in a building by as much as 15 per cent. but that the natural ventilation of occupied spaces may be almost entirely precluded by close metallic weather stripping of window sashes.

From these observations the conclusion is derived that the work of heating buildings closely follows variations of temperature, modified by the variations in wind velocity, the effect of this latter being dependent upon the number of windows and their construction, but being in all cases in the direction of an increase of the heat to be provided. This is found to be the case not only in a single exposed building, but in a large number of buildings grouped together. Thus, the Crawfordsville, Ind., district (hot-water) heating plant, has an established practice of a reduction of the temperature of the hot-water supply of one degree per degree rise of temperature above zero, of an addition of two degrees per one degree fall below zero, but these modifications are varied by the addition of one degree for each mile per hour of wind velocity.

The district-heating system of the Columbus Railway and Light Company also follows the same general practice with success, varying the amount of hot water pumped through the mains, as well as the initial temperature, in order to meet rise and fall in temperature with modifications to meet the velocity of the wind.

The study of wind effect has indicated that the heat transmitted through the building materials, due to the action of convection, is not materially enhanced by the movement of the air, because the action of convection in still air is always to establish a vertical current of heated air rising around the building, and the action of wind merely translates this vertical motion into a horizontal movement, at the same time creating on the lee side or sides a negative condition, re-



EXPLANATION.

The curves are the averages of the hourly variations of temperature and represent conditions of the Season of 1903 - 1904 which was a representative Heating Season closely following the average of thirty years observations in New York City.

By ascertaining the maximum heating requirements, at Zero, of any building, the vertical scale at the left can be used for Boiler horsepowers, from which the average requirments during any month, and for any hour of day or night can be read off on the scale.

Division of the Heating Season, New York City.

Month	Days	Holidays	Sundays	Workdays
October	16	—	2.20	13.78
November	30	2	4.20	23.70
December	31	1	4.40	25.57
January	31	1	4.40	25.57
February	28.25	2	4.00	22.25
March	31	—	4.40	26.57
April	15	—	2.14	12.80
Totals	182.25	6	25.92	150.30

FIG. 2. HOURLY VARIATIONS OF HEATING WORK FOR NEW YORK CITY AND VICINITY

ducing the motion due to convection and stagnating its action.

The method of defining the heat losses of any building which combines the elements of temperature and wind infiltration is therefore, for zero Fahrenheit exterior and 70 degrees inside temperature:

(1) Transmission losses.

W = Exterior exposed wall surface in square feet $\times$ 21 = heat units per hour;

G = Area in square feet of window openings $\times$ 70 = heat units per hour.

(2) Leakage to be heated from all sides of building.

L = Perimeter of window openings in feet for ordinary construction $\times$ 72 = heat units per hour. Perimeter of window openings in feet for metallic stripped sashes $\times$ 31 = heat units per hour.

The sum of all in heat units, plus 15 per cent. for line and pipe losses, divided by 30,000 equals the boiler horsepower required per hour to meet the most extreme weather conditions.

This total capacity placed on top of the diagram in Fig. 2 gives a scale by means of which all monthly hourly averages and totals may be ascertained.

As the lineal feet in the perimeters of the window openings plus the meeting rail is, in standard types of windows, equal to the amount of the area of the opening in square feet, the computation of wind leakage may be simplified by treating L as G, reducing the computation to

$$G \times 70 + G \times 72.$$

The methods above outlined have been interestingly confirmed by observations conducted by E. F. Tweedy, of the New York Edison Company, the results of whose investigations are shown in Figs. 3 and 4.

In Fig. 3 are plotted the actual consumptions of coal of a number of buildings related to a basis of their cubical contents. It will be observed that the plottings show no definite relation to one another, and that the rate of coal consumption per season per 1000 cubic feet appears to be the same in the case of buildings widely different in total cubical contents.

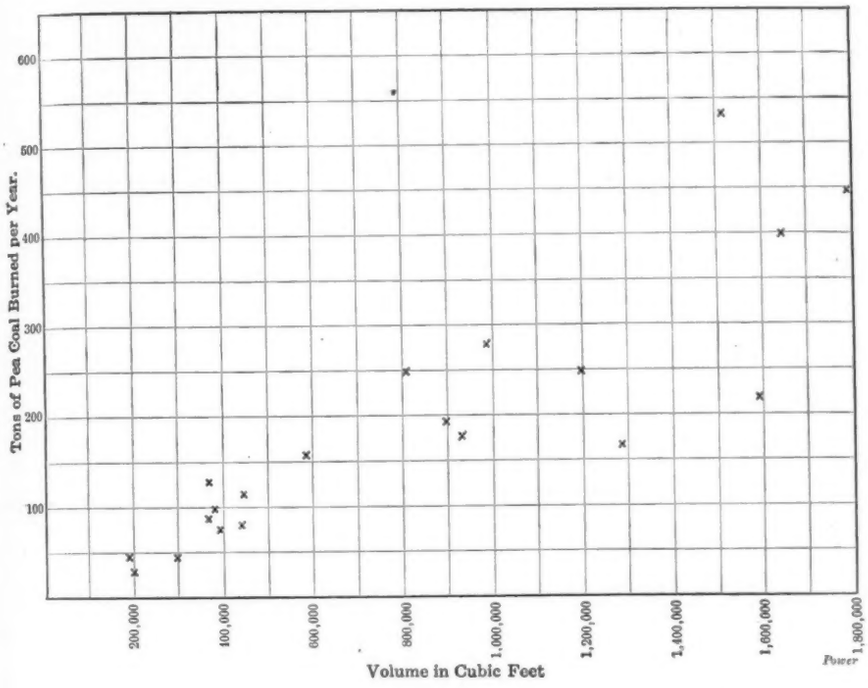


FIG. 3. RELATION BETWEEN COAL CONSUMPTION AND CUBICAL CONTENTS

The same cases show a harmonious relation when plotted as in Fig. 4 on a basis which takes into consideration the exposures of the buildings, with due allowance for air leakage.

The observations and deductions therefrom are, in part, thus described by their author:

At the outset, it was necessary to adopt an average ratio for the rate of heat transmission of glass to that of wall surface, and to obtain this it was, of course, necessary to adopt some thickness of wall as representing a fair average for loft and office-building construction in this city. Without entering into the details which led up to its adoption, I will say that a ratio of 4½ to 1 was finally adopted.

Realizing the uncertainty which arises in providing for the leakage loss on the basis of assuming an arbitrary number of air changes per hour, I decided to combine this loss with the transmission losses. Such a combination was deemed possible by the following line of reasoning: the leakage loss being proportional to the summation of the window perimeters (assuming the leakage space to be approximately constant in width) and the sizes of windows in similar types of buildings being fairly uniform, it becomes possible to consider the leakage loss as a function of the total glass surface without any very appreciable error.

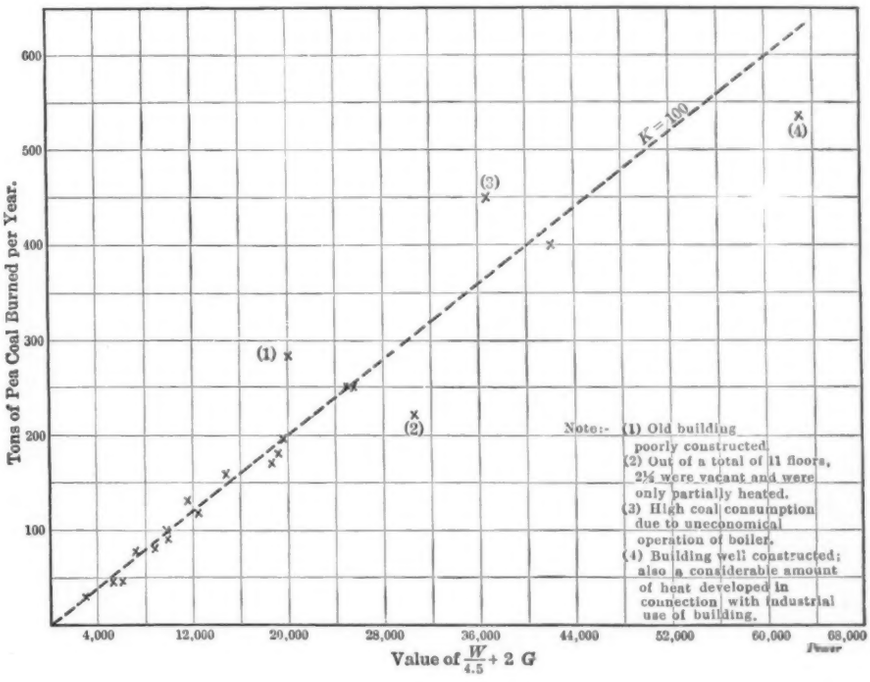


FIG. 4. RELATION BETWEEN COAL CONSUMPTION AND AREA OF EXPOSED SURFACES

Having made the foregoing assumptions, the following equation is obtained:

$$T = K\left(\frac{W}{4.5} + G\right) + K'G$$

where,

T = Tons of coal consumed per year;
W = Total exposed wall surface in square feet;
G = Total glass surface in square feet;
K and K' = Constants.

As it is not necessary to solve the above equation, K and K' need not be actually determined; for purposes of plotting, however, a relation between K and K' must be obtained. For $K = K'$ the equation evidently becomes

$$T = K\left(\frac{W}{4{\cdot}5} + 2G\right)$$

The relation between K and K' can be varied considerably without affecting the results to any appreciable extent, other than to alter the value of K. For $K = K'$, $K = 100$, which is a very convenient quantity for practical use. Fig. 4 shows the data for 20 office and loft buildings plotted from the equation in the above form. It will be seen that the values conform very closely to the equation as given. It will be observed that pea coal was burned in all of the buildings cited. Data were secured, however, from a number of buildings where the buckwheat coals or various mixtures were being used. All such cases—as would naturally be expected, due to the lower calorific value of such fuels—fall above the pea-coal line, but in most cases to a considerably greater extent than is to be explained by the difference in the thermal value of the fuels. I think that this can be accounted for by the fact that these poorer coals are very rarely burned under proper conditions as regards type of grate and draft, thereby nullifying the saving which might otherwise result from the use of a cheaper fuel.

For apartment-house buildings, the same general relation has been found to hold good, the only difference being that the value of the constant K is less, being about 60 instead of 100. This can doubtless be explained by the generally poorer construction of such buildings and by the fact that heating is required for more hours during the day.

Control of Condensing Water*

By B. Viola

In condensers of the jet type the efficiency depends upon the degree of subdivision of the cooling water, the quantity supplied and the length of the time of contact between the incoming steam and gases and the cooling water. This paper illustrates a design of condenser in which the first and last factors are maximum and a device for automatically regulating the cooling water supply so that the temperature of the discharge remains very nearly constant.

In the operation of the jet types of condenser it is often found that the injection of cooling water is unnecessarily increased at times by incorrect manipulation. Besides other visible indications of this mistake the temperature of the condensed water shows it most strikingly. When too much water is used the work of the air pump is made more difficult because of the air liberated from the water and if the pump is accurately proportioned for normal operation it is unable to accomplish the extra work. If

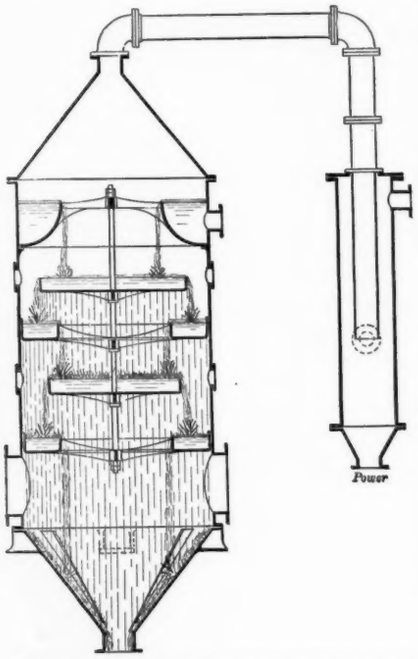


FIG. 1. CONCENTRIC COUNTERCURRENT CONDENSER

the pump is large enough, the work is accomplished, but at the expense of additional steam. If a wet-air pump is employed it is called upon to remove an excess of both air and water. Moreover, the excessive injection of water causes a higher pressure in the condenser. Assuming the falling water to be a liquid cylinder, the outer surface of this cylinder upon entering the hot steam takes up the heat of the steam, while the interior parts remain cool. If, owing to the great velocity of the fall, the water column is unable to effect cooling by the interior portions of the column as well as by the exterior surface, the heat of the discharged water will be too low. But if the equalization of temperature can be brought about through the whole water cylinder during the fall the cooling power of the water can be utilized more completely.

The more finely the water can be divided in falling the more readily will the gases pass through it and the resistance will be diminished as the surface is increased. The division of the water brings about to a great extent the escape of the air contained in the cooling water. This division, however, is never fine enough; hence, in countercurrent condensers the real counterflow takes place only upon the surface of contact between the water and steam.

The proper utilization of the cooling surface can only be provided for by a proper arrangement of the time of contact.

Theoretically, the time increases as the square root of the hight of the fall, but in the condenser the resistance increases with this hight.

The velocity of the water is governed by the hight of the fall and it is advisable to restrict this hight in order to prevent frictional resistance, if for no other reason. The smallest value of frictional resistance is obtained when steam and gases flow over standing water. Plants of such construction, however, would be too large. Moreover, water and gases being poor heat conductors when in a state of rest, it is necessary to provide for a certain degree of motion for water in a condenser.

Further, the quantity of steam condensed per unit of time is directly proportional to the cooling surface and a division of the cooling water is therefore equivalent to an extension of the cooling surface.

Therefore, to heat the condensing water quickly to the necessary temperature by direct contact with the steam, it is necessary (*a*) that the surface of the cooling water be large, (*b*) that the cooling surface change quickly, and (*c*) that the time of contact between steam and water be as long as possible.

To fulfil these conditions a concentric countercurrent condenser such as that shown in Fig. 1 gives the best results. This condenser is designed for use in connection with two or more vacuum pans. By the addition of basins or trays the duration of the contact between water and steam is raised, resulting in an economy of water. Some water will accumulate in each of these trays temporarily and the temperature is therefore equalized at each stage. The fresh supply of water will sink to the bottom of

*Abstract of paper read before the American Society of Mechanical Engineers, New York, December 6-9.

the tray, forcing the lower stratum upward on account of the difference in temperature, and the warmer water will flow over from one tray to the next. The trays in this manner form zones with the desired small difference of temperature and constitute a graduated scale from the temperature of the steam admission to that of the gas outlet. The surface of condensation depends primarily on the size of the cooling-water cylinder when the depth of the trays is greater than zero. It may even be said that these moving water columns promote the cooling and air and gases will pass at the surface of the trays even though they do not pass at the bottom. During the time the water remains in the trays it has a chance to take up more heat, which is withdrawn from the steam. It is very important that enough water be permitted to flow to secure good results, but by providing the trays with spray holes, the cooling effect of the water is considerably increased.

The work of the condenser varies with the temperature, but in general it performs about 610 times the work of the air pump, volumetrically speaking. It is absolutely necessary to exhaust the air and gases to promote condensation, but the best air pump cannot do good work with a poor condenser, while a good condenser accomplishes at least fair results with an indifferent air pump.

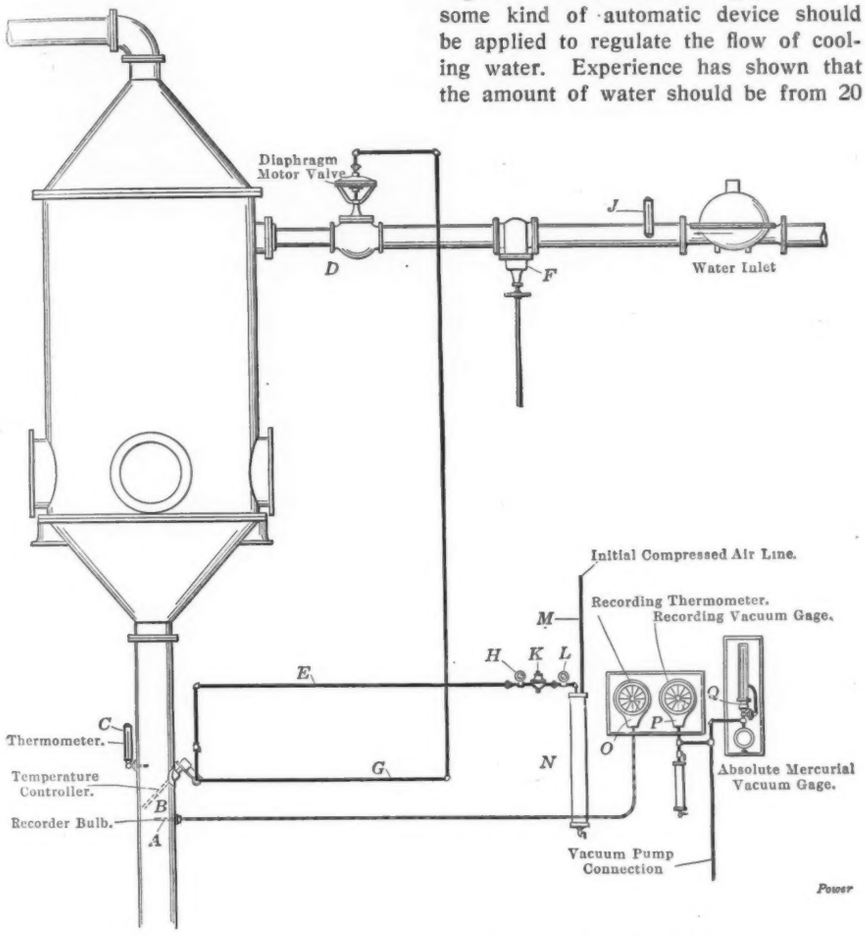


FIG. 2. DIAGRAM OF AUTOMATIC CONDENSING WATER CONTROL

ADVANTAGE OF AUTOMATIC REGULATION

It is very important that the right quantity of water be used to condense a certain quantity of steam. This matter is neglected in most condensing plants and some kind of automatic device should be applied to regulate the flow of cooling water. Experience has shown that the amount of water should be from 20 to 40 times that of the steam to be condensed. This is a very wide limit and in large condensing plants where immense quantities of cooling water are required some controlling device should be applied from an economical standpoint, so that water will not be wasted.

The first step is to decide at what temperature the water should be discharged from the condenser. This, of course, bears a certain relation to the steam to be condensed. I first applied a recording thermometer in the tail pipe of a concentric barometric condenser for the purpose of controlling the cooling water by hand operation of the inlet valve; but it was very difficult to convince the operator of the condenser that it was not necessary to let the cooling water run off cold, because it is generally believed the colder the water the higher the vacuum.

After experimenting for some time it was found very difficult to secure good results by hand regulation because of the continuous changes which must be made to meet conditions as the number of pans connected to the condenser is increased or decreased. This led to the application of an automatic temperature controller in the tail pipe connected to the compressed-air inlet valve, by which it was found possible to feed the condenser approximately in proportion to the steam or vapor which had to be condensed, resulting in a better average temperature of the condensed water and only slight variations.

By maintaining a nearly equal temperature of the condensed water, a very uniform vacuum was obtained except at periods when a new vacuum pan was charged.

CONSTRUCTION OF AUTOMATIC CONTROLER

The construction and operation of the automatic controlling device is shown in Fig. 2. The stem *B* expands and contracts in response to the temperature changes of the condensed water. The pipe *E* supplies compressed air of about 15 pounds pressure to the valve mechanism of the controller, from which it passes through pipe *G* to the water-inlet valve, where it actuates a regular globe valve *D* by means of a diaphragm motor which replaces the ordinary handwheel. The temperature of the condensed water affecting the stem of the controller permits all, a part or none of the compressed air to pass to the diaphragm-motor valve and consequently the latter is very nearly closed, partly open or wide open, according to the conditions prevailing, allowing the proper flow of water to the condenser.

Assume that the vapor pipe has been

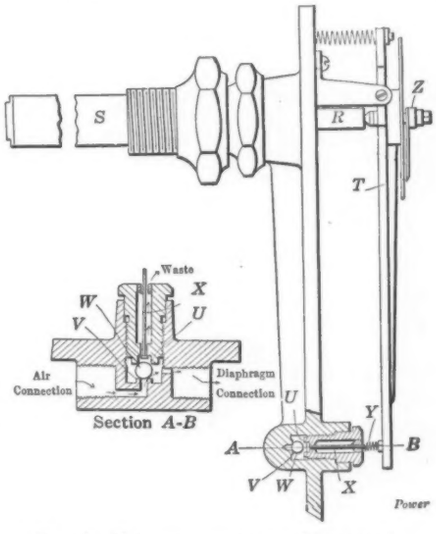


FIG. 3. CONSTRUCTION OF AUTOMATIC CONTROLLER

delivering an amount of vapor to the condenser which requires such an amount of water as will flow through the inlet valve when the latter is exactly half open. Should more vapor enter the condenser the temperature of the water passing through the tail pipe would, of course, start to rise, but as soon as the con-

troller stem was affected by this higher temperature it would expand and cause the valve mechanism of the controller to allow less air to flow to the water-inlet valve. Consequently, this valve would act to allow more water to pass through and thus maintain the proper proportion between the volumes of vapor and cooling water. The auxiliaries are; *J*, a thermometer to indicate the temperature of the cooling water; *F*, a hand valve for emergency use; *C*, a thermometer to indicate the temperature of the water passing through the tail pipe and serving as a check on the recording thermometer, which has its bulb at *A* and its dial at

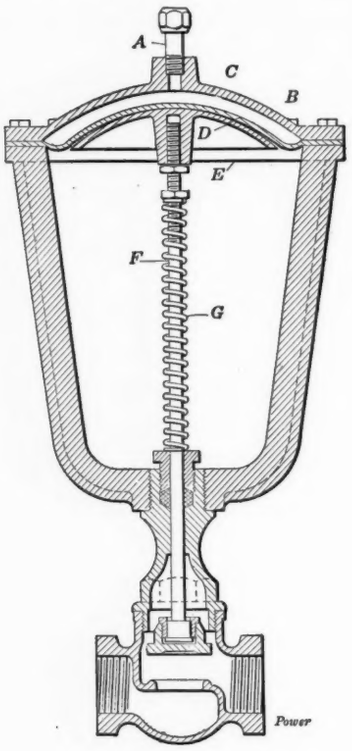


FIG. 4. SECTION THROUGH DIAPHRAGM MOTOR VALVE

O, and *P*, a recording vacuum gage, checked by a mercurial absolute-pressure gage, *Q*. The supply of compressed air in *M*, which ultimately operates the diaphragm-motor valve on the water inlet, enters the trap *N*, where any moisture or sediment is separated and which also acts as a storage reservoir. The gage *L* shows the initial pressure of the compressed-air supply, which is reduced by passing through the reducing valve *K* to the pressure required for the controller, as shown by the gage *H*.

Fig. 3 shows the very simple construction of the controller. The steam *S* is in two parts, the outer brass tube and the inner rod. The latter is composed of a material which has an extremely low ratio of expansion and therefore retains an almost constant length, regardless of temperature, while the outer tube, which is of brass, elongates or contracts in response to temperature changes. The tube and rod are so arranged that they are always in intimate though frictionless contact at the extreme end. At *R* is shown the extension of the inner nonexpanding member, which recedes when the outer tube elongates and advances when the outer tube contracts.

The movement thus obtained at *R* is transmitted by the lever *T* to the valve mechanism shown in cross-section. This is simply a three-port valve, shown more clearly in the section *A*—*B*, all ports of which are controlled by the ball *W*. The first port *V*, is the inlet for the compressed-air supply; another port, the second, connects with the line leading to the diaphragm-motor valve; the third port is the outlet for the air which has served its purpose by actuating the diaphragm motor. The position of the ball *W* depends upon the stem *X*, which is in contact with the lever *T* at *Y*. When the extension *R* moves outward due to the drop in temperature at *S*, the lever *T* is raised, and the stem *X* allows the ball *W* to leave the port *V* where the compressed air enters. The air can then flow through the second port to the diaphragm-motor valve, which starts to close. If a higher temperature acts upon *S*, expanding the outer tube and turning extension *R* inward, the lever *T* forces stem *X* against ball *W*. The latter then closes the port *V*, shuts off the air supply, and opens the third port so that the air can escape from the diaphragm motor. The diaphragm-motor valve consequently begins to open.

In actual practice, the diaphragm-motor valve is only completely closed or wide open if the conditions are such that the tendency is toward a sudden change in temperature. The controller is so sensitive that the diaphragm-motor valve is constantly throttling; that is, letting in just a little more or a little less water as may be required properly to effect the condensation.

If it is desired to change the setting of the controller, to maintain a higher or a lower temperature, it is necessary simply to apply a key to the part *Z* and by turning it one way or the other require extension *R* to travel more or less before the controller operates.

Fig. 4 shows the diaphragm-motor valve in section. This valve has a regular globe body, with a seat and disk arranged in the usual manner, but with a sliding stem that is operated by the diaphragm motor. The compressed air enters chamber *C* at opening *A*. This chamber is composed of a cast-iron top *B* and a rubber bottom *D*, called the diaphragm. The air pressure forces the diaphragm downward and the saucer *E* thus forces the stem *F* downward while compressing the spring *G*. When the air pressure is relieved the spring opens the valve again.

This installation has been the means of saving about $400 monthly for over a year in the charges for city water which was formerly wasted.

The question arises as to whether, with an equipment as described above, it is possible to attain a cooling-water rate near enough to that called for by theoretical formulas to be economical. Records of the water consumption as determined by meter readings show results very close to the theoretical and indicates great savings over the water required with former conditions of operation.

In sugar refineries, combined surface and spray condensers are usually employed. The vapor from the vacuum pan passes the surface condenser first for the reason that in case the vapor carries along some sugar particles, they will be condensed at that point and can be used to dissolve the raw sugar. In this way nothing is lost. The remainder of the vapor passes to the spray condenser, is condensed and flows down the tail pipe.

Condensers of this type require a considerable quantity of water and permit of great waste when no controlling device is employed.

Even where salt water is used waste should not be permitted because it increases materially the quantity of steam necessary for the operation of the pumps. In many cases where salt water is now used on account of the great quantity required, the use of a well constructed countercurrent condenser operated economically with a precise temperature controller may make possible the use of sweet water. This is a decided advantage where the condensed water can be used for boiler-feed purposes. I would not recommend its use in the same condition as when it flows from the tail pipe, in spite of the assertion that condensed water does not contain any impurities carried over from the source of the vapor. In steam-engine plants, for instance, it is well known that condensed steam contains oil, etc., and it is never pumped direct to the boilers. It has been determined from frequent analyses that condensed water from vacuum plants does not contain sugar or acid from the evaporation of acid liquor, but the so called untraceable losses in vacuum plants must necessarily be looked for in the condensed water. The quantity of water used is so great that the presence of these impurities is not noticeable, but practical experience has proved them to be present. However, when this condensed water at a high temperature (110 to 120 degrees) is passed through an efficient water-purifying plant, there is no doubt that it may safely be used for boiler feed.

When a gasolene blow-torch burner gets plugged up with dirt from dirty gasolene, it can be cleared by first removing the filling plug, then using a bicycle pump and forcing air into the burner, thus forcing the dirt back into the tank, from which it can be washed out.

Clearance and Compression

By Prof. R. C. Heck

A reply to Professor Dwelshauvers-Dery's criticism of the writer's original article appearing in the issue of September 13.

Because of pressure of work along other lines, the words of Professor Dwelshauvers-Dery upon the subject of compression in the issue of September 27 have just come to my attention, nearly two months after their appearance. Such complete misunderstanding is shown of the purpose, and in lesser degree of the substance, of my contribution in the number for September 13 that it seems desirable to clear up some of the points involved.

My discussion was intended to cover, in a brief and very general way, the whole question of compression and its effects; not merely the particular body of information furnished by the experiments upon the engine at Liège. The view taken of the latter would have been more clearly set forth by the statement—which formed the closing sentence of my introductory paragraph, but which was unfortunately subjected to editorial excision—that "the harmful influences here shown in such full play exist in all engines, but their effects are generally of a much lower order of magnitude." Even without this distinct disclaimer, there is no shadow of the contention, as regards the phenomena of heat interchange between the wall and the steam, that for small engines the laws differ from those observed in large engines (page 1740, column 1). Differences among engines exist, not in the laws of the phenomena but in the amount of their net effect.

Use of the Equilateral Hyperbola

Boyle's or Mariotte's law for the isothermal expansion of air, or of any practically perfect gas, is represented by the equation

$$PV = C;$$

but when this equilateral hyperbola is used as a steam curve it is not Boyle's law, and has absolutely no physical relation to that law or its conditions. In much of the traditional theory, the curve $PV = C$ is called the "theoretical curve of expansion" for the ordinary engine with saturated steam; this is a misnomer, because there is no rational theory of the action of the steam in the cylinder, whether when expanding or being compressed, and no curve can claim that title. Its appearance on page 1658, near the end of the last column, is another emendation.

The generally prevalent use of the hyperbola, as a standard of comparison for actual steam curves and in laying out preliminary diagrams, is fully justified and accounted for by the broad fact that in most engines the curves drawn by the indicator come close to this form. There are, of course, wide departures from constancy in the value of the product PV, under special conditions. As an extreme example, in the *Transactions* of the American Society of Mechanical Engineers, volume 10, page 751, is shown a diagram in which PV increases by 75 per cent. from cutoff to release. It was taken from a 17x30-inch engine, unjacketed and noncondensing, with steam at 33 pounds absolute, cutoff at 0.16 of the stroke, and a speed of only nine revolutions per minute; but at normal speed the expansion curve came back into close agreement with the hyperbola. On the other hand, in the *Transactions* of the American Society of Mechanical Engineers, volume 25, page 273, are given diagrams from an engine using a high degree of superheat which show a decrease of 25 per cent. in the value of PV from cutoff to release in the high-pressure cylinder; but here again, there was fair agreement with the hyperbola when the engine received saturated steam. The Dwelshauvers-Dery results constitute an extreme case for the compression curve, showing a shrinkage in PV which is far in excess of what is usual, even in small engines—compare Nos. 16, 35, 41, 42 and 54 in Barrus' "Engine Tests."

The First Assumption

Actual steam curves of expansion and of compression represent the resultant effect of very complex thermal interactions, complex, especially from the point of view of a rational, quantitative and perhaps synthetic theory. Indeed, it is doubtful whether such a theory will ever be developed much beyond the present rudimentary and almost wholly qualitative stage. In face of this condition, the use of a simple, average result like $PV = C$, as a first approximation and as the basis for some easy deductions, is very convenient and entirely proper. Relations in terms of this assumption can readily be modified so as to take account of closer empirical information.

In my presentation of September 13, the purpose of Figs. 1 to 3 and the accompanying text was twofold: First, to set forth the common theory in simple form; second, to develop a simple graphical method of representing the effect of changes in compression upon efficiency, in the curve KH, Fig. 3. Incidentally, the well known but often insufficiently emphasized fact is clearly brought out, that even for the ideal case of similar curves in expansion and compression the economical degree of compression depends upon the degree of expansion.

Of Figs. 4 to 6 and the related discussion, nothing need be said, as they merely fill out the presentation under the assumption of curves of the form $PV = C$. That the clearance steam has a negative work cycle of some sort is indisputable. Only Figs. 7 and 8 are directly concerned with the Dwelshauvers-Dery experiments and their bearing upon the design and operation of the engine.

Compression—Actual Curves

The point really at issue is summed up in the difference between the forms of the curve EF in these two figures. In a small engine at low speed the type of curve in Fig. 7 was obtained: the conditions favored a high relative amount of cylinder-wall effect, because small size means more metal surface per unit (weight) of steam handled, and low speed means plenty of time for heat transfer. In larger engines at ordinary speeds, or in small engines at high speed, while the action is of the same character as in this small and low-speed engine, it is relatively much smaller in amount.

Without absorption of heat from the steam by the cylinder walls, compression would be adiabatic; superheating would result and increase, and PV would increase progressively. In many engines, the heat absorption is only enough to lower the curve about to the form $PV = C$; in others, it causes the moderate decrease shown in Fig. 8; only under exceptional conditions does the kind of curve in Fig. 7 appear.

Probably the largest published collection of data from engines of the large-clearance high-compression class is the report of the locomotive tests made in the Pennsylvania Railroad Company's testing plant at the St. Louis Exposition of 1904. Two simple and six compound engines were tested, the clearance ranging from 9 to 18 per cent. (considering only high-pressure cylinders), and the speed from 40 revolutions per minute upward. Almost one hundred sets of indicator diagrams are reproduced in the volume of reports. In no case is there a sign of the hooked curve, except when compression goes above the admission pressure and a loop is formed; then, of course, it is difficult to isolate the effect of the cylinder walls from that of early opening of the valve for admission. But in many instances the less intense action evinced by the straightening of the com-

pression curve, as of EF toward F in Fig. 8, is strikingly apparent.

Suppose that the method shown in Fig. 3 is made complete by letting the ordinates represent the ratio of effective work to steam actually consumed, measured by test, the diagram being based on positions of the point E at which compression begins; the scheme will then be essentially the same as that of Figs. 3 and 4 (June 28 issue, page 1161), except that the ratios represented bear to each other the relation of reciprocals. Then curve KRH would have vertical ordinates, point K lying on the line AM, or corresponding to zero compression. According to the Dwelshauvers-Dery results, the curve would have its highest point at K and would descend steadily and with increasing speed toward H; in other words, the more the compression, the lower the efficiency. But in the absence of the tremendous condensation which causes the hook at the top of the compression curve, the saving of kinetic loss secured by moderate compression will certainly not be at once neutralized by increased cylinder condensation, and the curve KH will rise to a maximum before it begins to fall off.

To sum up, the simplified and incomplete analysis in Fig. 3 determines a certain degree of compression which appears to give the best economy. The successive introduction of actual and more closely empirical modifications brings R closer to K and lowers H, or shows that less compression is desirable and that the loss due to excessive compression will be greater. The essential contention that a steam action which makes even a small degree of compression cause net thermal loss is not normal and typical, but abnormal and extreme. This is all that was claimed anywhere in the article of September 13, and it does not seem to be seriously antagonistic to anything presented by Professor Dwelshauvers-Dery; even to express a slight doubt on the subject of leakage was not serious sacrilege.

Educational Program of N. A. S. E.

An important feature of the program for the coming season, prepared by the educational committee of the National Association of Stationary Engineers No. 37 at Dayton, O., is a printed circular containing numerous questions bearing upon the topics to be taken up at the weekly meetings. These are distributed in advance among the members and afford an opportunity for them to come prepared to take part in the discussion. Following is a partial list of the questions:

A list of questions relating to the topics to be taken up at the weekly meetings of association No. 37, of Ohio, during the present season. They are well worth looking over. See how many you can answer offhand.

Engines—Types

Classification—Types of modern engines; horizontal and vertical.

Name the different types of steam valves. Define the advantages of each.

For a 500-horsepower engine, which will be preferable, high or low speed?

Does the speed of an engine indicate any advantage in efficiency? Why?

Would there be any preference between the long-stroke or the short-stroke type?

What would be the maximum foot travel per minute of any piston?

Suggest the best points of cutoff for the highest efficiency, naming advantages.

Effect, if an engine were changed from one-third to two-thirds cutoff. Why?

Should there be any preference between a horizontal and a vertical engine?

What is meant by compound engines? Name advantages and economy.

Define difference and name advantages between cross- and tandem-compound types.

What should be an approximate ratio between high- and low-pressure cylinders?

Give the efficiency of the same engine on 100 pounds or on 150 pounds steam pressure.

Would a higher efficiency be secured by using condensers on an engine?

What gain in efficiency would be secured through a condenser? Why?

Is aid given to the steam piston by a vacuum? At 26 inches vacuum, how much benefit?

Name the best average vacuum obtainable through wet-vacuum pumps.

What is gained by covering steam cylinders with mineral wool and lagging?

How do we figure the horsepower and the steam consumption of an engine? Example.

Steam—Quality and Pressure

What is steam? Its chemical composition. Name the chief gases.

What gas predominates? Does dry steam carry water impurities with it?

Is low steam pressure as economical as high pressure? Why? Why not?

Would the same evaporation be required for steam at 100 pounds and 150 pounds?

Evaporating one cubic inch of water, name the volume of steam at 100 pounds and 150 pounds pressure with the steam piston 14 inches diameter; steam pressure 80 pounds; 550 feet piston travel, 100 brake horsepower.

Name the size of piston with steam at 150 pounds; 540 feet piston travel and 100 brake horsepower.

Can steam at 80 pounds be as dry as steam at 150 pounds? Why? Why not?

What percentage of moisture can steam carry without detriment to the engine?

What is superheated steam? Name process for superheating steam.

Does superheating the steam increase its pressure, or its expansive quality?

If expansive quality is secured, will it require as much steam as before?

What is meant by wire drawing the steam? Cause and effect.

What is the effect on steam if the reducing valve is placed at the throttle? Why?

What is the effect on a 14-inch piston if the pressure and expansive properties are increased?

Condensers—Types

What is a condenser? Its uses and advantages. Name types fully.

Should a condenser be selected to conform to local conditions of water?

Square feet of cooling surface required for each engine horsepower.

Define the process with a condenser, for returning steam to water.

How would you determine the quality of cooling water for a condenser?

Would the same amount of cooling water be used if the temperature differed?

Given cooling water at 60 degrees, and water at 75 degrees, name the amount required.

Does the temperature of condensation indicate the degree of efficiency?

What is vacuum; how is it obtained, how maintained and the maximum obtainable?

What is the vacuum required for average efficiency? Name the advantages of a high vacuum.

Could a vacuum be maintained at the engine without the use of a condenser?

Are cooling tubes of large or small diameter preferable? Why?

In what way do barometric condensers differ from surface and jet types?

Define the different ways cooling water is used in different types.

Does the quality of cylinder oils have any effect on surface condensers?

Name the standard ways for measuring vacuum. The most reliable way.

Condenser Pumps

Name types of pumps required in condenser systems.

Define the types, construction, uses and advantages of different types.

Is there any difference between a water pump and a vacuum pump?

Define the difference between a wet-vacuum and a dry-vacuum pump.

Does a wet-vacuum pump give as high a vacuum as a dry-vacuum pump? Why?

Can a wet- and a dry-vacuum pump be attached successfully to condensers?

Are crank and flywheel vacuum pumps successful as wet-vacuum types?

Have direct-acting steam duplex vacuum pumps been successful? Why?

What is termed slippage in wet-vacuum pumps? Is it necessary? Why?

How would you determine the vacuum for a given condenser?

Name the remedy for a vacuum pump's inefficiency, when it is drawing steam.

Electric Equipment

Define the general laws governing electricity. Classify the basic laws.

Do we create electricity, or only furnish means for its transformation?

What would be the effect, were a generator placed in a vacuum and run?

Are generators and motors affected by barometric conditions?

What is a unit of electric force? Define a unit.

State preference, if any, between alternating and direct current.

Advantages in either high or low voltage. What is the term voltage?

Define the difference between electric and magnetic forces.

Define the principals in generator and motor construction.

Does the number of feet of wire, and the number of coils regulate the capacity?

Describe transformers, their use, construction, advantages and necessities.

Describe exciters and boosters, their uses, necessities and advantages.

Describe storage batteries, their uses, construction, care, safety and capacity.

Describe the wiring of generators and motors, also commutators and brushes.

Normal rating of motor; name the possible overload without injury to the motor.

Is there any difference in the shock at starting between alternating- and direct-current types?

What is meant by "phase," "cycle" and "alternations?"

Of the alternating- or direct-current types, which is the more economical?

Refrigeration

What is refrigeration? Classify the types.

Name the earliest tried systems. Name refrigerating materials.

What is anhydrous ammonia; its source of supply and its boiling point?

Ammonia: its latent heat, its sensible heat, units of refrigeration.

Is the temperature of ammonia at 150 pounds pressure the same as steam at 150 pounds?

Describe the difference between the compression and the absorption systems.

What is aqua ammonia, and its use in refrigeration systems?

How are refrigerating plants rated? What is meant by a one-ton capacity?

Describe plate and can ice; their advantages, difference and which is the more economical?

Can both plate and can ice be made by the same system? If not, why not?

Name the functions of cooling coils. Are cooling coils and condensers the same?

Define the uses and effect of brine in refrigeration.

What is circulation, its necessity, how is it accomplished and give the strength of brine?

What are skimming and reboiling tanks, their uses and effects?

For each ton of refrigeration, how many pounds of ammonia are necessary?

What is the lowest possible temperature obtained through refrigeration?

Under ordinary care, can ammonia come in contact with the forming ice?

Define the cause of soft white or red core in ice cakes, and name the preventative.

Lubrication

Classify lubricants. Name the lubricants used before petroleum oils.

Would the steam-cylinder lubricants of 50 years ago answer now?

Have animal fats or oils been improved upon by petroleum products?

Define differences in crude oils, as found in different localities.

Can all crude oils be converted into cylinder oils? Why not? Why?

Define the difference between "dry and wet" distillation of crude oils.

Of the two systems, which is better?

Define the difference between pure mineral oils and compounded oils.

Where can pure mineral oil be used, and are there any pure oils used?

Do the temperature of steam and its quality affect cylinder oils?

What is known as "saponification" of cylinder oils? Name its cause and effect.

Give the meaning of the following terms: Specific gravity; viscosity, fire test.

From what part of petroleum do engine oils come?

What are the most desirable qualities in engine oils?

Are all engine oils filterable? Are filterable oils preferable? Why?

Are not more lubricating oils wasted than are really used or necessary?

Do you keep records of the oils used? Do you test the different oils you use?

Should oils be compounded from an analysis of conditions?

What causes a large part of so-called mineral oils to become rancid?

Suggest the best method for feeding cylinder and lubricating oils.

"Rules is Rules" on the Railroad

By E. Dixon

The man on the locomotive is guided by the signal and extremely rigid rules are enforced on the big trunk lines in regard to running by signals, even when they are out of order and being repaired. Defective signals cause train delays, which in the case of the fastest runs have to be very thoroughly explained, particularly if that special train is the pet of the grand high "panjandrum." In order to keep tab on the observance of the signal rules the "surprise test" is given at intervals. Some signal on the division is selected and, if in the day time, the blade is removed, while at night the lamp is extinguished or hooded. Then a note is made of all trains which fail to stop and investigate. Some moons ago the "president's pet" was a few minutes late and the moon shone bright as day; the light was out, but the paddle showed clear, so Fitzgibbon ran the signal and threw off a report at the next tower. It happened to be a surprise test and Fitz, like the others, got his little thirty days. The mere fact that he had brought his train in on time was not even an extenuating circumstance, nor the fact that it was not his regular run. The high mogul told Fitz, "Rules is rules." "All right," says Fitz, "you just can remember you gave the instructions."

Fitz's regular run was the one ahead of the flier when they pulled off the next test. The light was out and Fitz stopped; the inspector gave him a manual sign to go on but Fitz was obdurate; there was no light lit. Finally the inspector came down and was told Fitz would stay there till the light was lit. In the meantime the flier had crawled up on him and was telling him to get a move on in a most emphatic fashion. Cooney can pretty near swear with his whistle and he outdid himself then. The inspector climbed the pole, lit the light and cleared Fitz, who gave a derisive pull to his whistle as he started up. Fitz had the rules in back of him this time. The inspector could not claim the lamp was out of order, while the rule clearly said that the engineman must not pass the signal unless the light was lit. Of course, there were requests for the reason why the flier was laid out, but all they could get out of Fitz was, "Rules is rules."

Gas Power Department

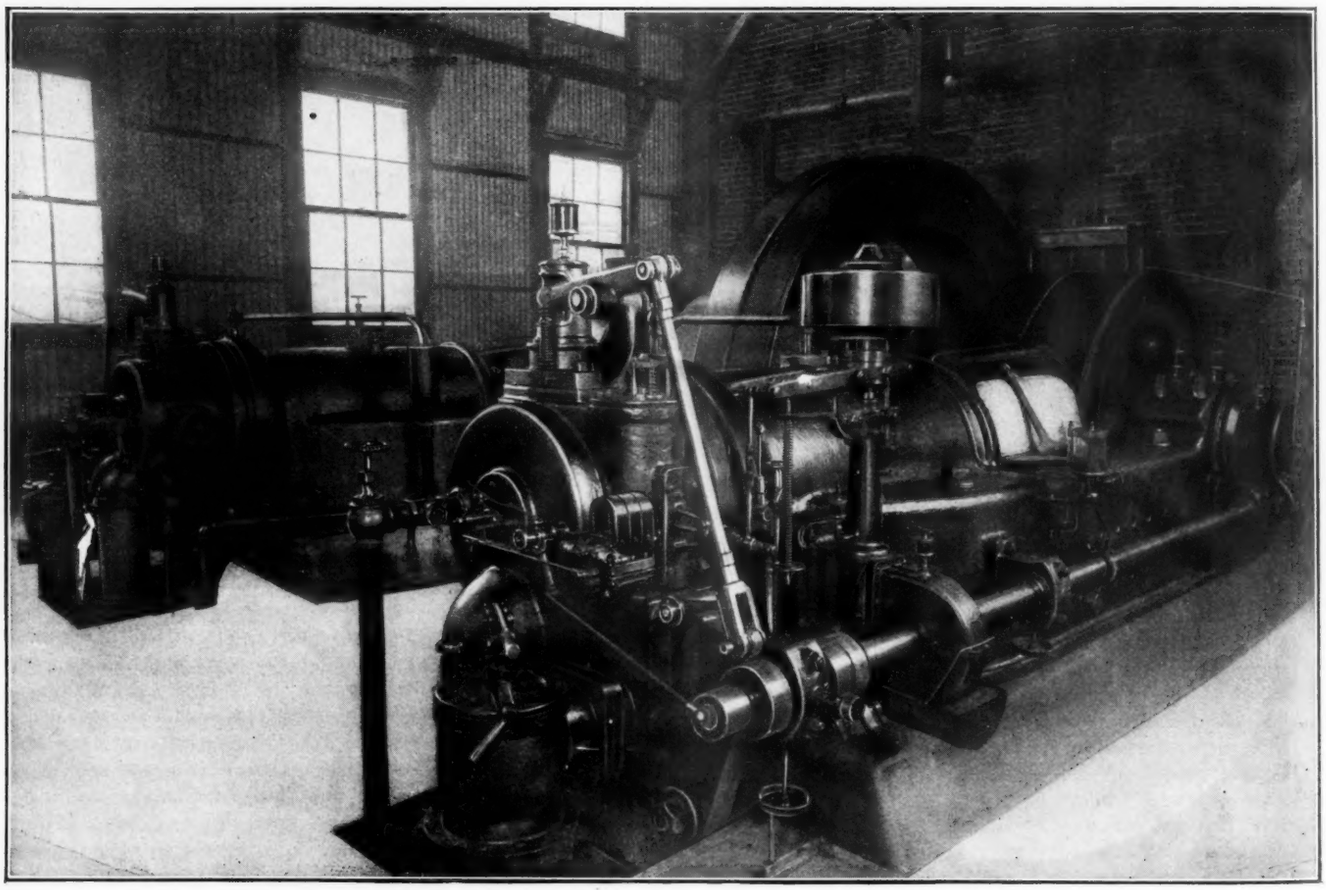
Performance of a Gas Power Plant Using Lignite

By A. M. Levin

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men.

The gas-generating apparatus of the power plant of the Olympia Brewing Company, Tumwater, Wash., consists of an up-draft suction producer of somewhat special form, a tower scrubber and a centrifugal gas washer, all designed and built by Peter G. Schmidt, mechanical superintendent of the Olympia company. The producer is specially adapted for operation on noncoking bituminous coals and lignite, which are mined in the State of Washington and are obtainable there at low prices. The generator lining is 72 inches in diameter inside, and the hight of the fuel bed ordinarily carried approximates 6 feet. The producer has been in regular service since April, 1909, with entire satisfaction, and for the past six months its fire has not been drawn.

The gas engine is a 20¾x32-inch single-acting twin-cylinder machine, rated at 250 brake horsepower when running 180 revolutions per minute, built by the Minneapolis Steel and Machinery Company. It is belted to a Triumph refrigerating ammonia compressor, with a cylinder 17x30 inches, and also drives, by belt, a 250-volt-direct-current generator. Fig. 1 gives a view in the engine room of the installation.



Twin Single-acting Engine Running on Lignite Gas in Washington

A few months ago a test was made to ascertain the efficiency of the plant as a whole under normal working conditions, and, as far as the facilities at hand would allow, the efficiencies of the engine and the producer separately. As the plant was operated with a very small load during the time of the test, as is generally done in the fall season, it was deemed advisable to add a water rheostat to the electrical load during a part of the test in order to obtain a total load somewhat more normal and better suited for the capacity of the installation.

A preliminary 12-hour test was made on August 15, 1910, and a final 24-hour test on August 23 and 24. Table 1 gives the average figures from the log sheets of the tests for each six hours' run, and the totals for each test. The second column of the table contains the averages of the electrical load in kilowatt-hours. From these figures and the efficiency of the engine and dynamo were computed the electric horsepower in column 3 and the corresponding brake horsepower at the engine, in column 4. The efficiency of the electric generator was estimated at 92 per cent. and the belt loss between the engine and the generator at 8 per cent. of the power transmitted; the reduction factor for the translation of electrical to brake horsepower, therefore, was

$$\frac{1}{0.92 \times 0.92} = \frac{1}{0.846}$$

The justification of this factor will appear later.

The mean effective pressures corresponding to the work of compression in column 8 were computed by means of the formula:

$$M.E.P. = 0.92 \times 3.5\, P_i \left[\left(\frac{P_f}{P_i} \right)^{0.286} - 1 \right],$$

in which P_i represents the absolute inlet pressure and P_f the absolute discharge pressure. The average mean effective pressures of the indicator diagrams from the compressor, which were taken every fifteen minutes during the test of August 23 and 24, are given in column 7 and it will be noticed that these average values and the average values obtained by the formula agree very closely. The mean effective pressures of column 8 of the test of August 15 can, therefore, be considered practically correct, although not corroborated by indicator diagrams. The figures for the indicated horsepower of the compressor in column 9 were computed for a speed of 49 turns per minute, which was approximately the average speed throughout the day's run. The brake horsepower in column 11 is that at the engine shaft corresponding to the indicated horsepower of the compressor, an allowance of 15 per cent. being made for friction in the compressor and 6 per cent. for loss of power in the belt transmission between the engine and the compressor. The reduction factor for converting the indicated horsepower of the compressor into brake horsepower at the engine was therefore

$$\frac{1}{0.85 \times 0.94} = \frac{1}{0.80}$$

As the basis for estimating the losses in the electric generator, the compressor and the two belt transmissions, a set of indicator diagrams taken from the gas engine during a two-hour run when the load was heavy and tolerably steady was used. The diagrams were taken simultaneously from the right-hand and left-hand cylinders and at reasonably even intervals. Observations of the electrical output as well as of the compressor load were made while the diagrams were being taken. The average figures for this heavy-load period were 84.41 kilowatts delivered by the dynamo, 95 indicated horsepower at the compressor, and 290 indicated horsepower in the two gas-engine cylinders. Apportionment of the gas-engine's work between the generator and the air compressor was determined by the individual figures from which the averages here stated were obtained.

Of course, nothing is proved with regard to the mechanical efficiency of the gas engine, but this factor is amply well known by experience with engines of the same build as the one tested. Because of the excellent condition of the cylinders and very thorough lubrication, it is reasonably certain that the mechanical efficiency of the engine was not lower than the 86 per cent. allowed in translating indicated horsepower into brake horsepower.

In order further to verify the correctness of the estimated losses of power between the gas engine and the driven machines for lighter loads, a set of indicator diagrams was taken during the period from 4.15 to 5 p.m. on August 15. The average indicated horsepower was 226, from which the average brake horsepower was calculated to be 194. On the basis of figuring losses just described, the brake horsepower required by the dynamo was 79 and that for the compressor 120, making the total 199 as compared with 194 actual. The discrepancy is not material.

Because of a misunderstanding with regard to the proper depth of ashes to be maintained on the grate of the producer during the test of August 15, the fuel consumption became unusually high, and an abnormally high percentage of unconsumed coal remained in the ashes. This test, therefore, is not of value as an independent efficiency test, but it is of importance as a preliminary test to that made on August 23 and 24.

The total coal consumption during the 12-hour test of August 15 was 4328 pounds or 360.6 pounds per hour for 192.5 brake horsepower, giving 1⅞ pounds per brake horsepower-hour and 1.61 pounds per indicated horsepower-hour. The average calorific value of the fuel as fired during this test was 7409 B.t.u., and hence the economy of the plant as a whole was 11,928 B.t.u. per indicated horsepower-hour.

The total fuel consumption during the 24-hour test of August 23 and 24 was 8730 pounds, or 364 pounds per hour for 235 brake horsepower, giving 1.55 pounds per brake horsepower-hour and 1.333 pounds per indicated horsepower-hour. The average calorific value of the fuel, as fired, was 7560 B.t.u. per pound, according to analyses, so that the economy of the plant as a whole was 10,077 B.t.u. per indicated horsepower-hour.

The engine jacket water was kept at approximately constant temperature during the tests, observations made at regular intervals showing the temperature of the discharge water to vary from 123 degrees at light loads to 129 degrees at heavy loads. The heat dissipated in the jacket water can, therefore, be considered to vary approximately in proportion with the load carried by the engines.

Careful measurements of the jacket water showed that the right-hand cylinder jacket discharged water at the rate of 5507 pounds per hour, at an average temperature of 128 degrees Fahrenheit and the left-hand cylinder jacket discharged water at the rate of 5850 pounds per hour, at an average temperature of 126 degrees. The total rate of flow was therefore 11,357 pounds per hour, or 6 gallons per brake horsepower-hour. The

TABLE 1. RESULTS OF TESTS.

Time.	Electric Load.			Compressor Load.						Total B H.P. at Engine Col. 4 + Col. 10	Total Coal Consumed, Pounds.	Coal per Hour. Pounds.	Coal per Hour per B.H.P., Pounds.	Coal per Hour per I.H.P., Pounds.
	Kilowatts.	Electric H.P. 1.34 × K.W.	B. H. P. at Engine E.H.P. / 0.846	Inlet Pressure, Pounds Gage.	Discharge Pressure, Pounds Gage.	M. E. P. From Cards.	M. E. P. Computed by Formula	I.H.P. of Compressor at 49 R.P.M. Col. 8 × 1.65	B.H.P. at Engine I.H P. / 0.80					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Test of Aug. 15.														
8:30 A.M. to 2:30 P.M.	55.079	73.8	87	13.875	155.25	.....	61.0	101	126	213				
2:30 P.M. to 8:30 P.M.	32.911	44.1	52	9.1	152.4	.....	57.5	95	120	172				
										385				
										192.5	3428	360.6	1.873	1.611
Test of Aug. 23 and 24.														
8:00 A.M. to 2:00 P.M	63.1	84.5	100	16.67	155.1	62.5	62.46	103	128	228				
2:00 P.M. to 8:00 P.M.	67.303	90.0	105	17.92	157.7	64.08	63.6	105	131	236				
8:00 P.M. to 2:00 A.M.	72.35	96.0	112	12.6	157.3	61.71	61.1	101	126	238				
2:00 A.M. to 8:00 A.M.	70.629	95.0	111	12.04	158.2	59.0	61.12	101	126	238				
										940				
										235	8730	364.0	1.55	1.333

inlet temperature of the water was 68 degrees, hence the total number of heat units carried away per hour was 669,700. The average horsepower developed by the engine during the time the jacket-water measurements were made was 239 brake horsepower, or 277 indicated horsepower. Hence, the heat loss in the jacket water was at the rate of 2418 B.t.u. per indicated horsepower, or approximately 95 per cent. of the heat converted into indicated work.

Facilities were lacking for determining the heat dissipated in the exhaust gases, but for engines of the same type as the one tested, with the valve gear adjusted properly, this item, together with the radiated heat, has been found to average practically 1.28 times the heat actually converted into indicated power. Assuming this ratio to be substantially correct, the heat distribution would be as follows:

DISTRIBUTION OF THE HEAT VALUE OF ONE POUND OF COAL.

	B.t.u.	Per Cent.
Total heat value of 1 pound of coal.	7560	....
Heat converted into brake horsepower	1642	21.7
Heat converted into indicated horsepower	1910	25.3
Heat dissipated in the jacket water	1814	24.0
Heat carried off in the exhaust and radiated	2445	32.3
Heat loss in the gas producer	1391	18.4

The thermal efficiency of the engine, accordingly, was 30.9 per cent. on the basis of indicated horsepower or 26.6 per cent. on the basis of brake horsepower.

The apparent unusually high efficiency of the producer, 81.6 per cent. on a fuel high in volatiles, is mainly due to the fact that the entire volume of the generated gas must pass through the zone of highest incandescence, and partly perhaps to the circumstance that the composition of the volatiles is such that they readily become changed into fixed gases in the apparatus, leaving the proportion of tar extracted from the gas less than 1 per cent. of the weight of the fuel.

During the test of August 15 the gas was sampled at intervals and chemical analyses made. Continuous calorimeter tests of the gas were also made, from 11 a.m. to 8:30 p.m. A fair average composition for the gas is obtained by taking the mean of the following two analyses:

ANALYSES BY VOLUME OF GAS SAMPLES TAKEN AUGUST 15.

	At 9 a.m.	At 3 p.m.	Averages
CO	17.2	15.2	16.2
CH_4	4.7	5.2	4.95
H	24.7	25.9	25.3
O	0.6	1.9	1.25
CO_2	11.2	2.7	6.95
N	41.6	49.1	45.35
High heat value, B.t.u.	184	186	185
Low heat value, B.t.u.	166	167	166.5

CALORIMETER GAS TEST MADE AUGUST 15.

	At 11 a.m.	At 3 p.m.	Averages
High heat value, B.t.u.	184	187	185½
Low heat value, B.t.u.	166	169	167½

The average heat values of the gas obtained by calorimeter tests during the period from 11 a.m. to 8:30 p.m. on August 15 were 185 B.t.u. high value and 167 B.t.u. low value. The condensation collected in the calorimeter was 0.016 of a pound per cubic foot of gas. The hydrogen and methane content shown by the gas analysis being unusually high for producer gas, it will be of interest to check these items by the weight of the condensation collected in the calorimeter. Each cubic foot of gas contained, on the average, $0.0495 \times 0.0422 = 0.0021$ pound of methane and $0.253 \times 0.00526 = 0.0013$ pound of hydrogen. The weight of water formed at the combustion of these gases should be $2.25 \times 0.0021 = 0.004725$ pound from CH_4 and $9 \times 0.0013 = 0.0117$ pound from H_2, making the total weight of water per cubic foot of gas 0.016425 pound. This computed weight of water checks very closely with the amount, 0.016 pound, actually obtained in the calorimeter, showing that the hydrogen and methane proportions given by the analyses are substantially correct.

The analyses of the gas showed it to be entirely free from any tar-forming heavy hydrocarbons, and this tar-free condition of the gas as delivered to the engine was also indicated by the non-luminous flame with which it burned upon being lighted at a 5-inch vent pipe near the engine.

A purity test of the gas was made on August 15 by passing 40 cubic feet of gas through a filter paper which before the test weighed 1.32 grams and after the test, 1.352 grams. The impurities abstracted therefore weighed 0.0320 gram, making the weight of impurities per cubic foot of gas 0.0123 grain.

The analyses of the lignite fuel used during the tests were as follows:

ANALYSIS ON AUGUST 13.

	Per Cent.
Moisture	17.6
Volatile matter	28.2
Fixed carbon and sulphur	31.9
Ash	22.3
Heat value, dry coal, B.t.u.	8992
Heat value, as fired, B.t.u.	7409
Color of ash, yellowish gray.	

ANALYSIS ON AUGUST 24.

	Per Cent.
Moisture	16.2
Volatile matter	28.9
Fixed carbon and sulphur	32.1
Ash	22.8
Heat value, dry coal, B.t.u.	9021
Heat value, as fired, B. t. u.	7560

The quantity of water used in the tar extractor for the cooling and cleaning of the gas amounted to about 4 gallons per hour per brake horsepower.

The question of using lignite as fuel for gas-power purposes being comparatively new and discussed infrequently, it may not be out of place in conclusion to emphasize the great ease and efficiency with which the fuel can be utilized in the producer. It cannot be claimed, of course, that the test I have described will prove that equally good results can be obtained from all lignites, because the composition of different fuels varies extensively, but as the situation is at present, and as a general proposition, it may be said that, for equal numbers of heat units utilized for power purposes in a suitably constructed producer, the efficiency of a lignite fuel compares favorably with that of any ordinary anthracite, and it will most likely prove to be superior to that of bituminous coal; and this in spite of the fact that its percentage of moisture will probably be 10 to 15 per cent. greater than that of the other fuels. What economy may under these conditions be derived from the use of lignite depends, of course, on the price per unit of heat value at which it can be laid down at the place that the lignite is to be used.

Considerable interest has been aroused by what is now frequently referred to as the "growth of cast iron after repeated heatings." Some difference of opinion as to the cause of this effect was at one time manifested, but in a paper on the subject read recently before the Sheffield branch of the British Foundrymen's Association, by Prof. H. Carpenter, this growth was definitely ascribed to the chemical reaction that took place between flame gases and the constituents in the iron, particularly the silicon constituent which has changed into silica. It was pointed out that another cause at work consisted of the gases which were dissolved in the iron itself originally, which also reacted with the flame gases. As the result of this enlargement, the iron to a very large extent lost its metallic properties, and became practically useless. In order to insure that iron should not grow in this fashion, it was explained that the silicon must be reduced to a very low figure, and there must not be any free carbon. The carbon must be chemically combined with the iron.

To prevent much of the pitting and corrosion in the dome of a pressure filter, or high portion of pipes containing warm or hot water, drill and tap at the highest point and put on a ¼-inch valve; no free oxygen or other gases can remain to attack the metal if this valve is allowed to leak a little water continually.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment.

Single Phase Transformer Connections

By Norman G. Meade

Alternating current is now used almost universally for electric light and power systems where the territory served covers a considerable area, because it has the advantage of being easily changed from a high voltage to a low voltage or *vice versa* by a simple and efficient apparatus, the transformer. This makes it practical to operate the transmission lines at high voltages and thereby secure maximum economy in the cost of the wires and at the same time avoid excessive losses in the transmission lines.

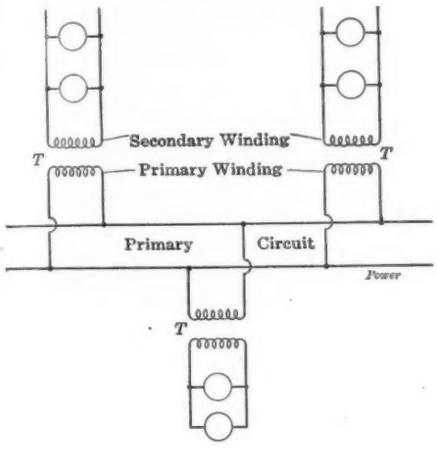


Fig. 1. Single-phase Distribution

The single-phase system is generally applied where the current is used mostly for lighting purposes. When, however, there is a large motor load the two-phase or three-phase system is preferable. A typical single-phase circuit for furnishing current to lamps and motors is shown diagrammatically in Fig. 1. The primary windings of the transformers *T* are connected in parallel to the high-voltage primary circuit and the current-receiving devices are connected in parallel across the low-voltage distribution circuits connected to the secondary windings of the transformers. This system automatically maintains almost constant electromotive force in the secondary circuits and permits the greatest flexibility of distribution from those circuits.

When a large load is concentrated at one place, the transformers may be "banked"; that is, the primary windings of several transformers are connected in parallel across the high-voltage circuit and the secondary windings are also connected in parallel, dividing the load between the several transformers. Fig. 2 shows three transformers connected in this way.

Transformer leads are generally connected to the windings so that the instantaneous direction of flow of the current in certain selected leads is the same in all transformers of the same type. For example, referring to Fig. 3, the transformer shown is connected inside so that when the current flows inward in the primary lead *A* it flows outward in the secondary lead *C*. Some such system is advisable in order that transformers may be readily connected in parallel; by this means it is only necessary to connect similar primary and secondary leads on different transformers for parallel operation.

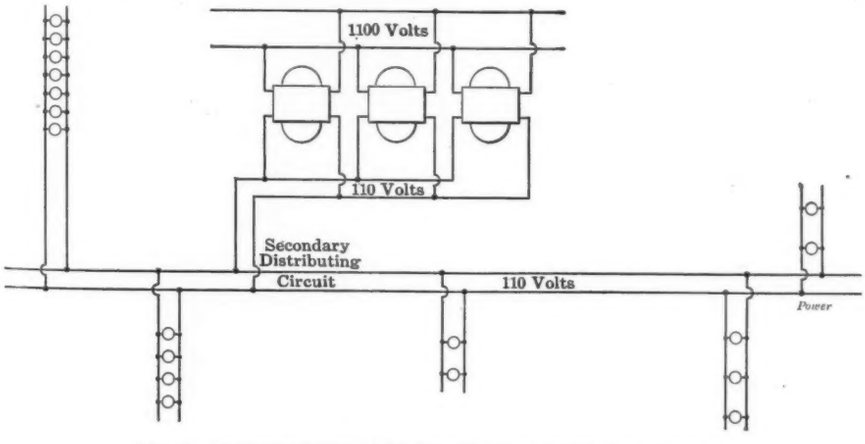


Fig. 2. Transformers "Banked" on Secondary Circuit

To make sure that a transformer is identical in this respect with other transformers of a different make, a polarity test is necessary. This is advisable to avoid the possibility of connecting the transformers in such a way as to short-circuit the windings. The polarity may be tested in the following manner: In Fig. 3, the primary lead *A* should be of the same instantaneous polarity as the secondary lead *D*. The primary lead *B* is connected to the secondary lead *D*, and an electromotive force of approximately 100 volts is applied to the primary leads *A*, *B*. The voltage measured from *A* to *C* should be greater than the applied voltage if the transformer is correct in polarity; if it is less, then the leads *A* and *D* are not of the same polarity, and either the primary or the secondary leads should be "crossed" if the transformer is connected in parallel with others which have the standard relative polarities.

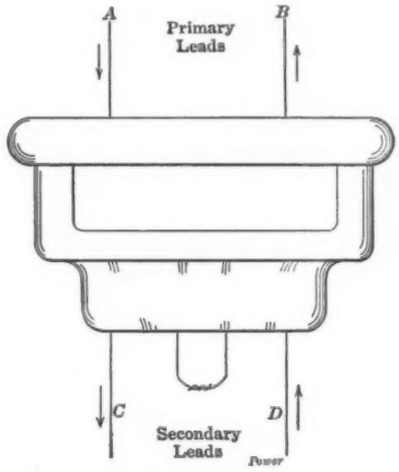


Fig. 3. Momentary Polarities

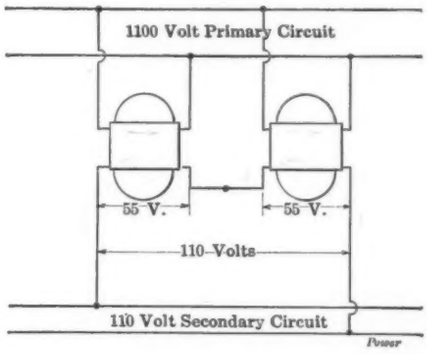


Fig. 4. Secondary Windings in Series

Sometimes it is desirable to connect two transformers with their secondary windings in series across the distribution

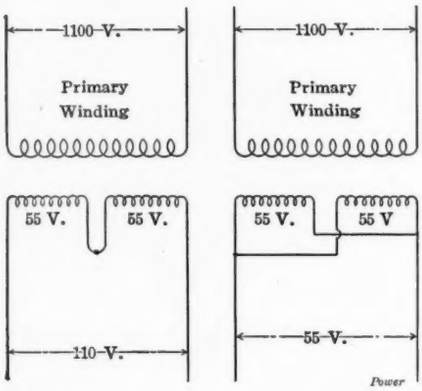


FIG. 5.

FIG. 6.

circuit, as indicated in Fig. 4. By this arrangement of connections, twice the secondary voltage is secured that would be obtained if the secondary windings were connected in parallel as usual. In connecting the secondary windings in series, those leads must be connected to each other which are of *opposite* polarity at any given instant. Otherwise the two transformers will oppose each other and no secondary current will be delivered.

Transformers are usually built with the secondary winding divided into two equal sections, and some have both primary and secondary windings divided. With a transformer having a divided secondary winding it is possible to obtain either one or two secondary voltages without banking, because the sections of the secondary winding can be connected either in series or in parallel. Fig. 5 is a diagram of a transformer with two secondary windings connected in series, which gives a secondary voltage twice as high as that obtained when the secondary windings are connected in parallel, as represented in Fig. 6. The same precaution against short-circuiting the windings has to be observed as when separate transformers are banked.

The object of providing a divided primary winding is to allow the transformer to be used on either of two voltages, one twice the other. For example, if each half of the primary winding is designed for 1100 volts, with the two halves connected in parallel the transformer can be used on an 1100-volt primary line, and by connecting the primary windings in series the transformer may be used on a 2200-volt line.

THREE-WIRE DISTRIBUTION

In Fig. 7 two separate transformers are represented, each wound for a voltage ratio of 10 to 1; that is, 1100 volts to 110 volts, and connected at the secondary leads so as to supply a three-wire system with a voltage of 220 between the outside conductors. The secondary windings are therefore connected in series, giving 220 volts between the outside leads. A lead is carried from their point of juncture to the neutral conductor of the three-wire system, in order to obtain the secondary voltage (110) of each transformer between the neutral and each of the main wires. This method of connection gives a system which is almost the exact equivalent of the regular direct-current three-wire system. The secondary windings of the transformers correspond to the armatures of the direct-current dynamos. The only point in which similarity fails is in the voltage regulation. Both of the direct-current dynamos can be regulated, and independently of each other, but the transformer voltage cannot be regulated at all except by the use of very special, complex arrangements.

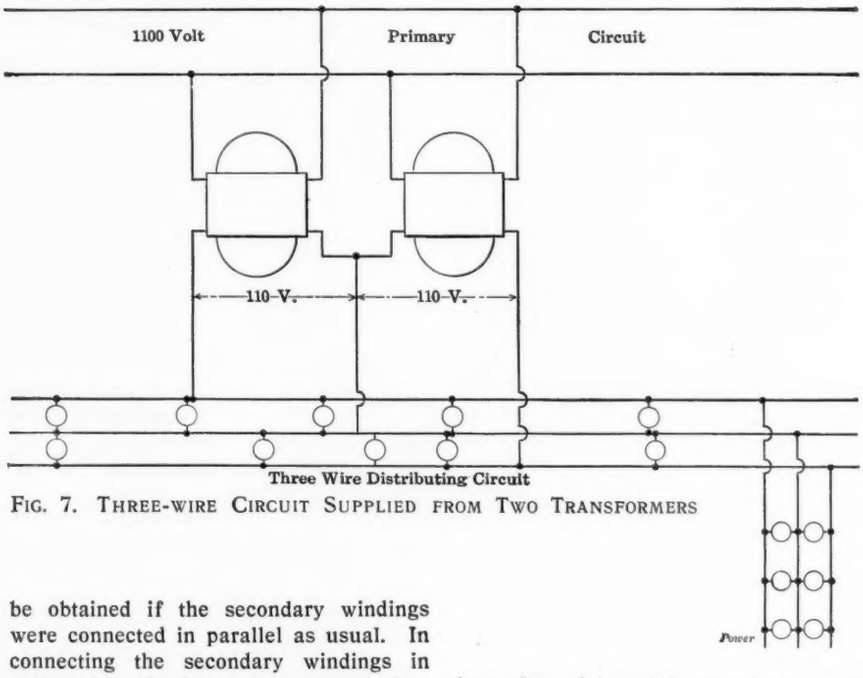


FIG. 7. THREE-WIRE CIRCUIT SUPPLIED FROM TWO TRANSFORMERS

Fig. 9 shows still another method of connecting transformers for supplying a three-wire secondary circuit. The main transformer *T* is connected to the outside wires of the three-wire system and a balancing transformer *B* is connected to all three wires near the center of distribution. The current capacity of the balancing transformer need be only enough to carry one-half of the greatest difference in load between the two divisions of the system. A balancing transformer for this purpose is merely an autotransformer with an intermediate tap midway between the terminals of its single winding; this tap is connected to the neutral wire, as shown. If one-half of the three-wire system is loaded more than the other half, there will be a corresponding increase in voltage drop on the heavily loaded side. The half of the balancing transformer connected to the lightly loaded side of the system will aid the half connected to the heavily loaded side and tend to raise the voltage to normal. Its operation corresponds to that of the balancing set used on a three-wire direct-current system with one dynamo.

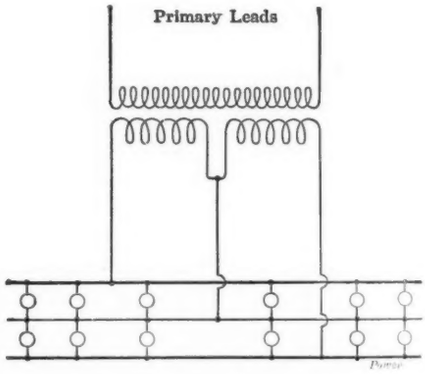


FIG. 8. THREE-WIRE CIRCUIT SUPPLIED FROM ONE TRANSFORMER

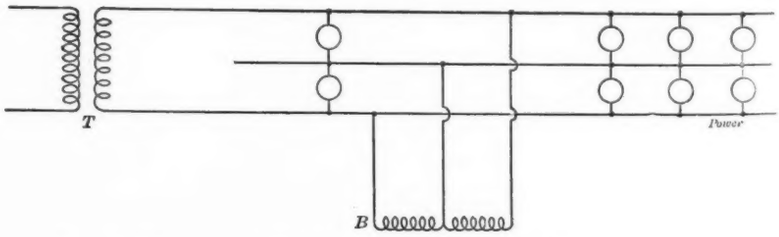


FIG. 9. THREE-WIRE SYSTEM WITH BALANCING TRANSFORMER

LETTERS

Circuit Breaker Alarms

Referring to Mr. Blomberg's letter on this subject, published in the issue of December 6, it may be well to point out the fact that it is not at all necessary to attach a live connection to the circuit-breaker handle, as my diagram showed it. The arrangement can easily be modified so that when the circuit-breaker opens the handle will strike an insulated lever and close the switch in the alarm circuit. My diagram merely represented the system as it was actually in use.

In view of the fact that the system is in use and has been for a number of years, Mr. Blomberg's assertion that the bell will not ring with the three lamps in series is rather hasty. However, it is only fair to him to explain that 50-volt lamps were used because the filaments are thicker and therefore more substantial than those of standard lamps. His argument that the failure of a lamp will disable the system is, of course, true, but it applies also to his own system. If one of the three lamps in parallel should go out, the current will be reduced to about 70 per cent. of the normal, which would not ring the bell properly unless the normal current were excessive.

Mr. Blomberg's system is open to the objection that the alarm will be operated by any failure of the main current or by the breakage of one of the connections between the relay and the main circuit, whereas the system I described can be operated only by the opening of the circuit-breaker—the event which the system is used solely to indicate. Moreover, the Blomberg system cannot be applied to several circuit-breakers without using as many relays as there are circuit-breakers, which would be expensive and entail a considerable clutter of small mechanisms.

GEO. W. MALCOLM.

Brooklyn, N. Y.

Governor Adjustments for Engines Driving Alternators in Parallel

When operating alternators in parallel I have found that if the governors are adjusted to give 3 or 4 per cent. drop in speed from no load to full load, the operation of the machines will be more satisfactory than if the speed regulation is closer. Some engineers favor close regulation, and this is all right for direct-current work, but for alternating-current machines 3 or 4 per cent. is better. It is a hard matter to set the governors so they will act exactly alike, and if they are adjusted to regulate very closely between no load to full load, any discrepancy in responsiveness will be a much larger percentage of the total variation than if the latter were greater; consequently, a small difference in the action of the governors will produce a larger difference in the load division than it would with less sensitive regulation.

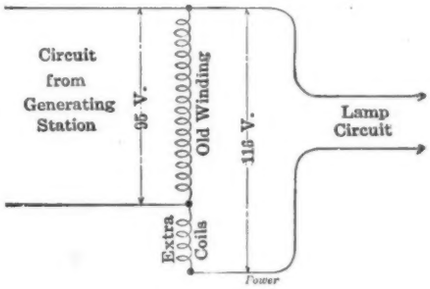
The engine governors should be so adjusted that there is no tendency to cause a transfer or surging of the load from one engine to another. This action may be caused by a sudden variation of the load, or by the angular variation of velocity in different parts of the revolution which is common to most reciprocating engines. If the governor is equipped with a dashpot it should be kept full of oil thick enough to prevent the governor from being sensitive enough to respond to such disturbances, but still not thick enough to prevent the governor from acting under the influence of a reasonable and definite change in the speed of the engine.

R. L. MOSSMAN.

Tampa, Fla.

An Improvised Alternating Current Booster

It frequently happens that some means of raising the voltage on a feeder or a single distribution circuit, without altering the busbar voltage of the system, is very desirable. Where direct current is used, the only way to raise the voltage of one part of the system alone is to insert a booster dynamo, which is expensive. In an alternating-current system, however, the voltage can be boosted or lowered by means of a transformer or an autotransformer; when the amount of



BOOSTER CONNECTIONS

boosting is small, an autotransformer is preferable.

On one occasion in our plant a "lame" circuit was boosted from 95 to 116 volts by using the secondary winding and core of a 50-watt instrument transformer, the primary winding of which had been burned badly. The remains of the primary winding were removed from the core and the secondary winding was increased by 25 per cent. more turns and connected to the weak circuit as shown by the accompanying diagram, making a simple autotransformer of it. The secondary winding originally contained 32 turns of No. 22 wire, and we added 8 turns of No. 18, that size being used because the full-load current had to pass through that part of the winding. The additional wire reduced the heating and gave us a point to connect in the 95-volt tap without disturbing the insulation.

The potential at the extreme terminals of the "booster" was 118 volts at no load, but the drop brought it down when the load was on, and the load was either all on or all off, so that the question of regulation was not important. This little improvised booster has been supplying six incandescent lamps satisfactorily for several months.

WELDY S. YEAGER.

Colgate, Cal.

Mr. Gorilla's Induction Motor and Flickering Lamps

The trouble described by Mr. Gorilla in POWER for November 22 is probably due to slippage. When overloaded, the motor momentarily increases its slip and takes a heavy current from the mains, and then runs slightly above speed. This effect is called "hunting" and causes the lights on the circuit to flicker, due to the current in the motor being leading or lagging. A leading current causes the lights to burn brightly while a lagging current decreases their brilliancy. The trouble spoken of would be expected from a synchronous motor more than from an induction motor.

THOMAS H. WATSON.

Chicago, Ill.

[An induction motor cannot "hunt" under any conditions; on the contrary, it acts as a damper when the system shows a tendency to "hunt." If Mr. Gorilla's voltage fluctuates, the motor will follow the fluctuations but never lead them; neither will it take a leading current, unless driven as a generator considerably above synchronous speed. The fluctuations in voltage may be due to a sticky engine governor or to a load on the motor involving heavy reciprocating masses which during a part of their travel drag the motor above synchronous speed; but not to hunting inherent in the motor. —EDITOR.]

Bill Grimes et sum dried apples fer lunch tother day an' then crawled inter his biler t' titen up a loose brace. He got sorter het up, an' ast th' fireman t' hand 'im in a drink uv water. Well, when th' water an' them dried apples got t'gether thar wuz sumthin' doin' in Bill's interior department. He jist swelled up like a pizened pup an' when he tried t' crawl out he wuz jist 'bout four sizes too big fer th' hole. He laid in th' biler all th' arternoon with his hed stickin' out an' cussin' a blue streak while he wuz waitin' fer th' apples t' digest. Th' boss told 'im thet arter this he'd better eat a chunk uv alum fer his lunch 'fore he went inter th' biler so he'd sorter pucker up 'stid uv swellin'.

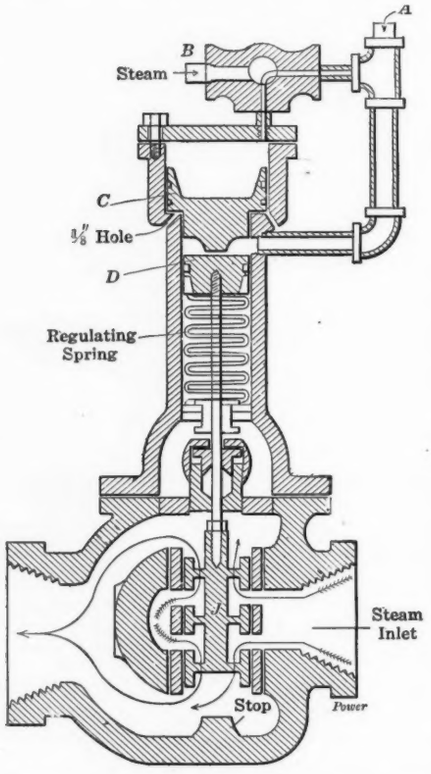
Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words, wanted.

Safety Stop for Pressure Regulating Valve

When a pump is controlled by a pressure-regulating valve there is danger of injuring the pump, should the discharge pipe or any of its connections break, as the regulating valve would instantly open wide and turn on a full head of steam and probably wreck the pump, as has occurred in a number of cases which have come under my observation.

Because of this, I set about to devise some means to overcome this danger, and I believe I have effectually accomplished



SECTIONAL VIEW OF AUTOMATIC SAFETY STOP

this by means of the device illustrated herewith.

The inlet water pressure from the discharge main enters through the connection *A* and the three-way cock *B*, which is normally open from the connection *A* to the top of the piston *C*, which is open to steam only when just starting, as there is then no water pressure on the pump to hold the stop piston *C* in place.

A leather cup piston *D* actuates the balance valve *J* due to the pressure from *A*. The stop is to prevent a too far downward movement of the balance valve *J*. Should the discharge main break, or the pressure be suddenly relieved from the pipe *A*, the spring would force the pistons *C* and *D* to the top of the cylinder. When in this position steam would be shut off by the balance valve, thereby stopping the pump.

B. U. POTTER.

Holyoke, Mass.

Troubles of a Refrigerating Engineer

In some of the mechanical ice machines that were built about ten years ago, it was the custom to install a small pump, driven from the engine shaft by a belt, to supply the oil for the stuffing box through which the piston rod works.

The oil for this pump is stored in a recess under the rod and is pumped into the gland, and in most cases considerable oil is carried through into the compressor. This was the case with the machine that I had charge off. On the discharge side of the compressor is placed an oil collector, also a rectifier, but the quantity of oil that was carried over into the compressor was so great that it was impossible to remove the oil from the rectifier as fast as it was carried over and, as a result, considerable oil was carried into the expansion coils in one room of the warehouse. The system of cooling was composed of coils of pipes suspended from the ceiling and fed by two ½-inch pipes with a regulating valve attached at the point of entrance to the expansion coils.

During the hottest part of the season the temperature began to rise in this room and I noticed that only one-half of the pipes were frosted over. During my search to locate the trouble, I found a pocket in the liquid pipe that fed this series of coil. On taking this lead pipe down, I found it clogged at the drop or pocket with a mixture that, when analyzed, proved to be oil and wearings of the cotton packing I was using in the piston-rod stuffing box of the compressor.

To remedy this trouble I devised a sight-feed lubricator and placed it on the machine and piped the pump to the lubricator. After installing the lubricator, the rectifier was kept going, and before I had caught up with the system nearly two barrels of oil had been recovered that had been hidden away in the recesses of the refrigerator coils.

At another time it was reported to me that there was a smell of ammonia in one of the cellars, and it was found that ammonia was escaping from the stem of the regulating valve. When attempting to take up on the packing a little more, I broke the bonnet. Warning the men who were working in the cellar to get out, I made for the engine room and shut off the supply of liquid and, closing off the rest of the suction valves, pumped on that set of coils until a vacuum had been secured. Then, supplied with a new valve, I went to the cellar to make the repair, after securing a large towel, saturated with water, over my mouth and nose, and a rope secured around my waist, leaving the end at the door in the hands of my assistant to pull me out in case I was overcome with ammonia, the new valve was put in place. This experience put me wise to the fact that cast-iron valves on a refrigerating system were not the best, and I took the first opportunity of changing them in my plant for those of steel construction.

Another experience made me do some thinking before I located the trouble. We have three suction valves on the machine I had, also three regulating valves conveniently placed in the engine room. One side of the machine is used for the direct-expansion system and the other is used in conjunction with brine tanks, centrifugal pumps, fans, etc.

It had been my custom on going off watch at night to shut off the direct-expansion side of the machine, as it was not necessary to run it continuously to secure the required temperature. I closed it off one night and instructed my night engineer as usual, but was called to the plant about 11 p.m.

I found the compressor shut down and all the information I could get was that the machine ran hot on both suction and delivery sides and had done considerable groaning in starting up. After securing a vacuum on the suction side and a low pressure on the condenser, it was plain that the machine was not getting any ammonia, and upon looking at the regulating valve that led to the direct-expansion side, I found the valve open about one-half turn. This explained the trouble, for the liquid ammonia had all been forced into the system that was closed off. Opening the suction valve by degrees and running the machine slowly for an hour or so, I got things back into normal condi-

tions. The night engineer admitted that he had opened the valve as the pressure was a little too high on the condenser, but had closed it when the pressure had been reduced on the condenser.

W. G. WALTERS.

Stratford, Can.

Washing Boilers Externally

I would like to read the opinion of POWER readers on washing boilers externally. In one plant, containing water-tube boilers, each boiler is cut out of service by order of the superintendent about every four weeks and, as soon as it is cool enough to permit, a man is sent in on top of the tubes with a hose and all the ashes and soot washed down from the drums and tubes. The boiler is also washed out inside and is then inspected by the superintendent. This method of cleaning the tubes is used on account of the boilers being set so close together there is not room enough to get a blower of the proper length in between the tubes to properly blow the ashes from the tubes; they were blown to the opposite side and sometimes the space between the tubes was found packed solid in places, thereby decreasing the efficiency of the boiler.

There are several points for and against this practice. The boiler can be more easily and thoroughly inspected. Tube renewals (which are at short intervals here) can be more easily made as well as any other repairs to the boiler and setting, and under these circumstances, inspection and repairing are not dreaded as much as they are otherwise, and as the boiler is quite cool before the water is put on, the walls are not cracked by sudden contraction. The firebox lining usually lasts about one year with the boilers working at an overload one-half the time and seldom less than three-quarters load.

The objections against this practice are that it is liable to cause the setting to settle and crack the walls, and it takes more coal to get the boiler setting up to the working temperature again. No serious results have occurred in this plant to my knowledge after two years of this practice.

Several of the engineers' books say that "water must not touch the outside of the boilers, as it will cause corrosion." This is caused by the sulphuric acid in the soot combining with the water and attacking the iron, but in this case the soot is all washed off and, as the walls are warm and the draft is left open, the moisture remaining on the walls and tubes is soon evaporated, and after standing idle a week, the rust or corrosion on the outside of the tubes and drums can be easily wiped off by hand.

J. CASE.

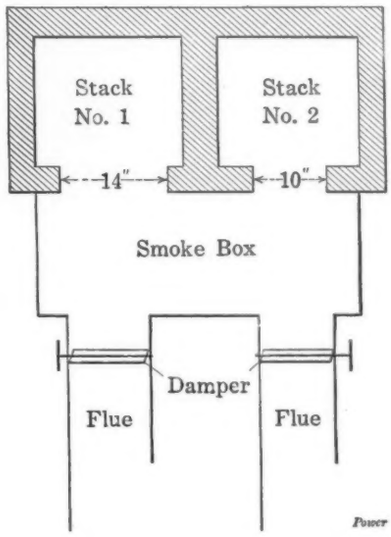
Hyattsville, Md.

Chimney Problem

With two smokestacks of equal hights and cross-sections as shown in the figure, will the hot gases pass up the stack with the larger opening and draw cold air down the stack with the smaller opening and hamper the draft?

The stacks serve two boilers of the locomotive type of 50-horsepower rating each. The stacks are 22 inches square and 40 feet high.

Would it be advantageous to divide the smoke box and so have one stack for each boiler and thus interrupt a circuit



ARRANGEMENT OF CHIMNEYS

of air from one stack to the other? Or, would one stack be sufficient to serve both boilers, thus allowing the other to be cut out?

L. G. WATRY.

Pueblo, Colo.

Why the Engine Stopped

While working for a threshing-machine company last summer I was sent out to find and eliminate the cause of a peculiar binding in an engine that would run smoothly for some time and then suddenly begin to bind and after a few more revolutions stop. Then the threshing crew would try to turn the band wheel to throw the crank over the dead center, but could not move it.

Then the engineer would go over the engine, feel of the bearings, perhaps make a few adjustments, as he had seen the old engineer do, pump some cylinder oil into the steam chest, then try again to move the band wheel as one man could turn it easily, but the trouble would return.

They concluded the oil pump was not doing its work, so purchased a new one, but in vain.

An expert was called and after two days' hard work making several adjustments confessed he could not fix the engine, and returned home.

It was then that I was called to try my luck.

The water used in the boiler came from various sources, some from a flowing well of mineral water, some from a surface well of alkali water and some from a flowing stream impregnated with considerable vegetable matter.

The boiler foamed badly and with a decrease of pressure or increase of load the engine would pick up a volume of water and the piston would begin to groan.

They were also using a loose hemp rope of a very poor grade for piston packing, and when the engine primed the water would be forced out around the piston rod and wet the hemp, which would swell and grip the rod; but after standing a few minutes the heat from the rod would dry out the packing and cause it to release its grip upon the rod.

I advised blowing off frequently, washing down regularly three times a week or else use one kind of water and wash once a week, keeping the steam at a high pressure and about one gage of water, and getting some good grade of piston packing.

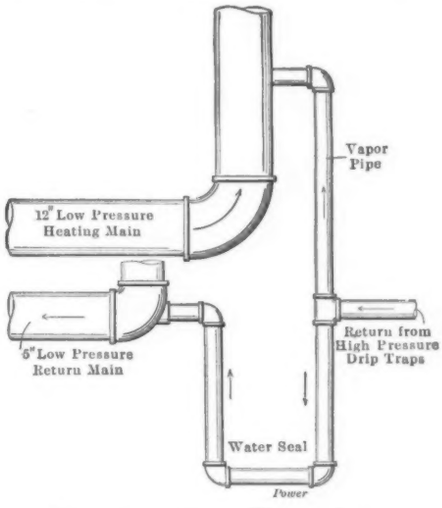
WILLIAM E. PIPER.

Farmington, Utah.

Connecting High Pressure Drips to Heating Mains

The plant at which I am employed had about fifteen high-pressure traps discharging to the sewers at various points about the main and adjoining buildings.

When our supervising engineer tried to get an appropriation to put in a return line recently it was refused, as the lawns and asphalt would have to be dug up



CONSTRUCTION OF WATER SEAL

to put in a pipe and conduit to the boiler house 500 feet distant.

While discussing the problem our boys hit on a plan that worked out successfully.

A return line varying from ¾ inch to 2 inches in diameter was run through

the cellars to the point where the main return left the main building for the power house. This line was connected to a water seal about 4 feet deep, from the top of the seal on the inlet side. A 2-inch vapor or equalizing pipe was run to the low-pressure heating main to prevent any steam or pressure blowing the seal out into the return to cause water hammer.

Now it is possible to heat with ½ to 2 pounds pressure (Paul system), and the vapor from this high-pressure drip now helps to heat the buildings instead of the sewer. We saved digging up the lawns and driveways and the cost of 500 feet of pipe and the labor of putting it in.

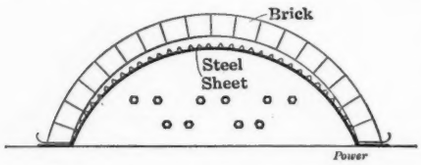
W. T. MEINZER.

Brooklyn, N. Y.

Sheet Steel Brick Support

While looking over a couple of old boiler settings recently, I came across a method of covering a boiler that I think is worth passing on.

The usual practice when bricking in the top of a return-tubular boiler is to lay the bricks directly on the boiler shell. But the boilers referred to, which had been in service for 25 years, had an arch



BRICKS SUPPORTED OVER BOILER

formed by sheets of steel sprung over the top of the boiler and supported on the side walls as shown in the accompanying illustration. This arch carried the weight of the brick covering and provided an air space between the boiler and brickwork. This opening was closed up at each end to prevent air from circulating between the boiler and the steel casing. This arrangement also served to prevent any water that might drop from overhead valves and piping from soaking through the brickwork to the boiler shell.

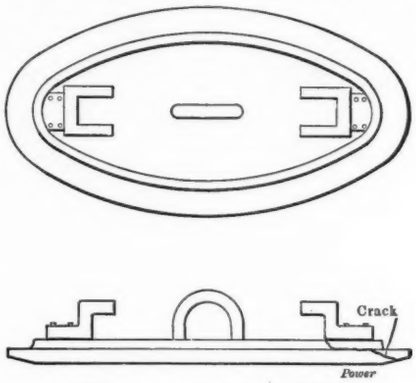
CHARLES FENWICK.

Qu Appelle, Can.

Cracked Manhole Plate

A new 66-inch by 18-foot tubular boiler was put in a plant three years ago and I had more or less trouble with the bottom manhole in the front head, which leaked, and was due, I thought, to the rough surface, the countersunk rivet heads or a blow hole in the cast-iron plate.

A few weeks ago I washed the boiler and a few drops of water leaked out around the gasket when the plate was in place. On a closer examination I discovered that the leak came from inside the flange that was riveted to the manhole plate. When the boiler was again empty, I took a sledge and broke the manhole plate and found a crack on



MANHOLE PLATE CRACKED

the outside of the manhole plate half way through the flange of cast iron, as shown in the illustration.

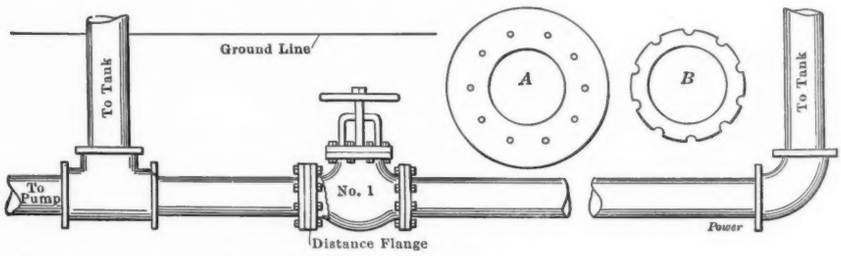
G. A. GUSTAFSON.

Chicago, Ill.

Using a Distance Flange

At the plant where I am employed there is a duplex pump which discharges through a 5-inch line, over the tops of two tanks, each 30 feet high, one being 75 feet from the pump and the other 200 feet.

Last winter the ground settled and caused a 5-inch gate valve to break, as shown in the accompanying illustration. The old valve was taken out and another ordered, but in connecting up it



SHOWING DISTANCE FLANGE IN PLACE

was found that the new valve was ½ inch short.

As the pressure in this line never exceeds 30 pounds it was decided that the ½-inch space could be taken up by a ½-inch pine board, made in the form of a distance washer as shown at *A*. Everything went fine till the next afternoon, when the joint sprunk a leak. Another piece was put in which held for about the same length of time.

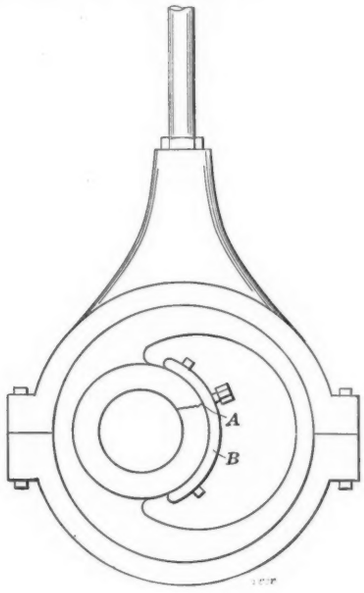
The third trial resulted in a disk made of wood and formed as shown at *B*. The flanges were pulled squarely up, making a comparatively flexible joint, and the job is still holding.

B. F. HARTLEY.

Tipton, Cal.

Repairing Broken Eccentric

The accompanying sketch shows how a repair was made to an eccentric of a wet-air pump, which cracked at *A*, through the hole for the adjusting screw. A steel plate *B*, 5/8 inch thick, and as wide as the eccentric body, was bent to conform to the curvature of the eccentric, and four



REPAIRED ECCENTRIC

½-inch holes were drilled in it, corresponding holes being tapped in the eccentric to receive set screws which held the plate firmly in place. The hole in the plate for the adjusting screw was tapped, the old thread through the break being drilled out. This secured the eccentric against any possibility of shifting on the shaft. After the valve was set, the shaft was cupped out about ⅛ inch under the adjusting screw.

HENRY W. RANDALL.

Saginaw, Mich.

If short a reducer on threaded cold-water pipe, one can easily be made by first stuffing the fitting with oakum and pouring in babbitt metal where the bushing should be; when the babbitt has cooled the oakum should be removed and the newly made bushing and pipe should be made up with a pipe wrench, to prevent leakage from shrinkage.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues.

Effects of Cold Air

In reading POWER I often see articles relative to firing methods in which the boiler plates are subjected to chilling drafts. Of course, this is rightly condemned, as there certainly is no benefit derived from admitting cold air to a furnace through the fire doors.

It is well known that a vessel containing boiling water does not get heated to a very high temperature relative to that of the fire.

Now, in the case of a boiler, how could cold air from an open fire door damage the plates? In my opinion, before the air could strike the plates, it would be heated to even a higher temperature than that of the plates over the grates. And, certainly, before it could reach the tubes, it would be hot enough so as not to do any harm.

H. C. FISKE.

North Yakima, Wash.

Thermometers versus Gages

C. H. Peabody's article in a recent issue on "Thermometers versus Gages" has suggested to me the desirability of using the thermometer to serve as a check for the gage.

When the fire is started under a boiler which has been out for cleaning or repairs, the steam gage is depended upon to indicate when the boiler should be cut into the line. If the gage fails to indicate the pressure correctly, the safety valve calls attention to the trouble. However, should the safety valve stick, which sometimes happens, there is a good chance for an explosion.

Perhaps there are not many instances when the steam gage fails to indicate the pressure correctly, but I have had this occur five or six times when steam was being raised.

After the first occurrence the gage pipes were blown out twice a week. But this did not stop the trouble. The boilers are of the water-tube type. The gage pipe is ¼ inch in size and tapped into the steam drum on top and brought down over the front. When the pipe was blown out the water was thick and black and seemed to choke the small pipe.

I am going to increase the size of the pipe to ⅜ inch and use an angle valve on the nipple which screws into the boiler. With this arrangement the pipe can be disconnected and cleaned with a wire.

A thermometer to show the temperature of the steam in the boiler would serve as a guide in case the gage pipe should become clogged.

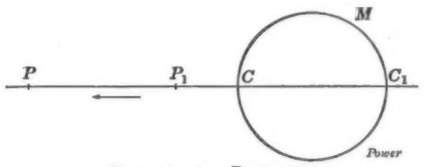
P. L. WERNER.

McKeesport, Penn.

Does the Crosshead Stop?

In the November 22 issue, Mr. Fryant asks, "If the crosshead does not stand still, how can it stop?" and refers to questions and answers relative to this in "Stevens' Mechanical Catechism."

A more satisfactory geometric proof that the crosshead does not stop will be



CROSSHEAD DIAGRAM

made apparent by observing the accompanying figure.

Let P and P_1 represent the positions of the crosshead center when the crank-pin center is at C and C_1 respectively. When the crank pin is approaching the point C, the velocity of the crosshead is gradually decreasing, until the point C is passed, when the crosshead begins its return stroke. If C had a dimension, length, the motion of P might be altered, but as C is a point without dimension, formed by the intersection of two lines, P cannot theoretically stand still, as the progress of C around the circle M is not stopped.

The only time when P could stand still would be when C stood still or moved in an arc whose radius was PC, described about P as a center.

CHARLES M. ROGERS.

Detroit, Mich.

In the issue of November 22 appears a question regarding the motion of the crosshead. A quotation from a catechism is given to the effect that the crosshead does not stand still at dead-center points; and the writer of the letter asks how the change of direction can be made without a stop.

The answer in the catechism appears to me to have this fallacy in its reasoning: the crank pin is always moving and therefore the crosshead which is connected to it must move also. In the accompanying diagram C—D represents the connection between pin and crosshead. The pin is moving in the direction A—B, which for a very small distance is at right angles to C—D; therefore, at this instant, it is impossible for the pin to produce any motion at right angles to itself through the connecting rod. The crosshead cannot be moving in either the direction H or K at this particular instant, and, hence, must be standing still.

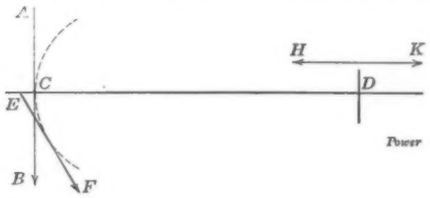


DIAGRAM OF CRANK-PIN TRAVEL

When the pin has passed on, its momentary direction will be along E—F, which, by shortening the distance between the pin and D, causes motion of the crosshead in the direction K.

In actual time the stoppage is very short, but it exists nevertheless, while the motion of the pin through C neither shortens nor lengthens the horizontal distance C—D.

H. S. BURROUGHS.

New York City.

This question can be settled in a very simple manner if it is assumed that the motion of the crank pin is uniform. With this as a basis, a velocity curve can be plotted for the crosshead, motion in the direction of the crank being plotted above the base line and motion in the opposite direction below the base line. The length of the base line represents the distance which the crosshead moves while its velocity at any point will be represented by the distance from the base line to the curve. The shape of this curve will show that the crosshead velocity decreases to zero and immediately commences to increase, and that this change from positive to negative direction occurs just as smoothly as do numerous changes in velocity at other points in the stroke.

This crosshead question is very similar to the older one about the barrel of wine. Half of the wine being consumed, the barrel was refilled with water. This sequence of operations was repeated. The problem is: How long was it before the barrel contained nothing but water? Should the crosshead actually stop when the engine was at top speed, things would commence to happen immediately.

Why is a cow?

E. DIXON.

Cleveland, O.

I note in the issue of November 22 the letter by H. J. Fryant regarding that old question, "Does the Crosshead Stop?" I fail to find any good clear argument in favor of its not coming to a dead stop, for when rotary motion is converted into rectilinear motion there must certainly be a cessation of the latter motion every time the rotary part, viz., the crank, reaches the end of its throw. This interval of cessation may be longer or shorter, dependent, of course, upon the radius and speed of the rotating part and the length of the connecting rod. It seems to me to be a very simple thing to find the solution of this problem as it is utterly impossible for an object advancing in a straight line to reverse its motion and return over the same line without first ceasing to move in the original direction. The crank-pin center is an established fact notwithstanding all arguments to the contrary. Or, to be more explicit, there is a dead point at each end of the stroke when the crosshead ceases to move while the crank pin is moving across the line of crosshead travel.

Of course, the time consumed by this operation or the length of the cessation of motion may be 1/10 of a second or 100 seconds, dependent, as before stated, on the speed, etc. But, the fact remains that the crosshead is at rest for a certain period of time. As an aid in understanding this, let any engineer turn an engine over slowly until the crosshead ceases to move. Make a mark on the flywheel as when using a tram to find the center when setting the valves, and then turn the wheel until the crosshead commences to move in the opposite direction.

CHARLES H. TAYLOR.

Bridgeport, Conn.

In the issue of November 22, under the heading, "Does the Crosshead Stop?" Mr. Fryant wants to know how the crosshead of an engine ends one stroke and begins the next, going back over the same line on which it came out, without coming to rest for a short period of time while the crank is passing the dead center.

Mr. Fryant has brought up a question concerning which there is a conflict between the practical and the theoretical answers. Speaking in a practical sense, the crosshead does come to a stop at the end of every stroke. But, from a theoretical point of view the following explanation will, I think, "put him straight" and be of interest to other readers who have not before given this problem much attention.

If the crosshead should come to rest, assuming that the connecting rod fits the pins accurately at both ends, the only motion that could be given to the free end of the rod would be that of an arc with the crosshead pin as a center. From this it is evident that the crosshead cannot stand still while the crank end of the rod is passing along any portion of the crank circle. The crosshead does, however, reverse its direction and return along the guides. But, if it cannot come to rest in changing its direction, the change must be accomplished by the crosshead describing a loop. The exact shape of the loop depends on the type of engine and the valve setting. The width of the loop is equal to the amount of clearance between the guides and this, of course, is very small in actual cases.

Every operating engineer knows of the pounding that will take place if this clearance is of any appreciable amount and every good engineer calls it his business to see that there is only enough clearance barely to avoid heating. So, for engines that are properly adjusted, the amount of clearance is negligible. The loop is then so narrow that it may be disregarded altogether and the travel of the crosshead may be taken to be back and forth along a straight line with a full stop for an infinitely short period of time at each end of the stroke.

E. O. SMITH.

Newport News, Va.

Pumping Problem

I was much interested by the pumping problem presented by J. Ellethorn in the November 15 issue. If the 2½-inch well pipes are connected to the bottom of the 5-inch suction, when the pump is started a vacuum will be created and the following will occur:

When the vacuum reaches 8.8 inches the water from the 10-foot well will reach the 5-inch suction pipe. When the vacuum reaches 10.6 inches the water in the 12-foot well will reach the 5-inch suction line and the 10-foot well will be delivering nearly 100 gallons per minute. If the pump is speeded up until the pipe in the 22-foot well is full, and the water in it neither flowing up nor down, the other three wells will be delivering far in excess of 235 gallons.

If the vacuum is any less than 19.4 inches or that represented by a 22-foot head of water, there will be a flow of water from the 5-inch pipe into the 22-foot well and if the vacuum becomes less than 15.8 inches there will be a flow into the 18-foot well.

It will be seen, then, that this would be a very poor system. The down pipes must be connected through goose necks to the *top* of the 5-inch suction.

Then, when the vacuum reaches 12.4 inches or 8.7 pounds per square inch absolute pressure, the water in the 18- and 22-foot wells will rise in the 2½-inch pipes 14 feet above the surface of the water in their respective wells and the other two wells will be delivering about 235 gallons per minute, 140 gallons from the 10-foot well and 95 gallons from the 12-foot well.

By feeding the 5-inch suction from the top, the pump will receive all of the water discharged from the wells.

A. LANGMAN.

Aurora, Ill.

Removing Clinkers

W. N. Wing, in the issue of November 22, speaks of the use of oyster shells in removing clinkers from a boiler furnace. The theorist with high ideals for the fire room does not consider clinkers as really necessary attributes of a boiler or gas producer; but, like the poor, they are always with us. The little ones do not cause trouble but the big ones do. Coal ash is largely composed of silica and alumina, the same elements which make firebrick refractory, and in this fact lies one of the reasons why clinkers have such a firm attachment for the sides of the firebox. The fusing point of the clinker being only slightly lower than the fusing point of the firebrick, the clinker when plastic readily unites with the fire-softened surface of the brick.

The "why" of the efficacy of oyster and clam shells in assisting in the removal of the clinkers lies in their being composed almost entirely of lime, which causes them to act as a flux for the clinker, reducing its fusing point. A too liberal use will cause the clinker to get lime bound and infusible at furnace heats. Oyster and clam shells, however, are not to be found in the vicinity of most boiler rooms in any quantity, since the present high costs of living have largely eliminated the succulent "raw" from the fireman's bill of fare. This is no reason for despair, however, as a very efficient substitute for such shells, limestone, can be obtained at the nearest iron foundry. This will do the work of fluxing the cinder as thoroughly as it acts as a flux in the cupola.

E. DIXON.

Cleveland, O.

Power Plant Design

In regard to the letter by Waldo Weaver in the November 29 issue, I think that it would indeed be an ideal power-plant layout that could not be improved upon, and I believe that it is true in many instances that faulty arrangements are made as the results of the notions of some doctor, lawyer or other person having no mechanical inclinations whatever who happens to be the fond owner or an influential director.

I was once called upon to operate a new plant in connection with a woodworking shop which had been laid out under the direction of one of the directors of the concern, who was a lawyer by profession and who thought that he knew quite a good deal mechanically. A consulting engineer with no practical experience but having a college degree was

employed to work out the plans because, I suppose, being a well educated, cultured professional man who knew how to charge for his services, his personality appealed more strongly to the lawyer than did that of a grimy, greasy operating engineer.

The plant contained an old-style Wetherill-Corliss engine of about 150 horsepower capacity, a second-hand engine but in good order. The flywheel was 12 feet in diameter and carried a 24-inch leather belt driving a 5-foot pulley on a jack shaft. The center of the jack shaft was only 17 feet distant from the center of the engine shaft, and there was, consequently, but little belt contact on the 5-foot pulley. The engine was set up on a subbase of concrete 16 inches above the floor level, and a short step-ladder was required to enable one to reach the throttle.

The boiler grates were placed level with the floor of the boiler room, with a pit 2 feet deep and 4 feet wide, covered with iron slabs which could be removed when it was necessary to clean the fires or the ashpits. These pits extended to the outside of the building and comprised the air ducts to the furnaces.

The plant was in operation when I was engaged to take charge as operating engineer. But, although the machinery in the shops was not more than half installed, the engine would not handle the load required of it at the time. The main belt gave considerable trouble by slipping and it was hard to keep up the steam pressure.

After my first inspection of the plant I told the manager that I was going right back to my old job, that I had never seen so ridiculous an arrangement before. He wanted to know if I could make some changes in the arrangement so that the plant could be operated. He said that he had expected it to be a modern, uptodate plant, that an expert mechanical engineer had been retained at considerable expense in anticipation of this, but upon giving the plant a trial he was sadly disappointed in the engineer's work.

I told him that I would stay if they would remodel the plant, and after a consultation with the owners, I was told to go ahead with my changes.

I had the concrete subbase under the engine removed and the engine set 4½ feet further away from the jack shaft, making a total distance of 21½ feet between centers. A new 6-foot pulley was substituted for the 5-foot one and the engine speeded up from 60 to 72 revolutions per minute. I had the floor of the boiler room lowered 20 inches and a truck made with an iron spout at one end from which the fuel could be fed to the fires very handily.

After these changes had been made, the plant was operated with greater satisfaction, and when the full equipment of machinery was installed, there was enough power available for all requirements.

Consulting engineers say the operating engineer is not competent to plan, because he is prejudiced, narrow-minded and lazy. He is apt to want things too handy in order to make his routine work easier, and he does not take into consideration the cost of things. But, however that may be, I have had experience enough to know that the more handily and more conveniently a plant is arranged, the more efficient will the human element be.

Of course, due consideration should be taken to the costs, and it is not impossible for the operating engineer to equip himself with the ability of estimating costs and the profit or loss to be incurred by the installation of this or that machine or appliance.

The operating engineer is not, perhaps, in a position to acquire so wide a knowledge of all kinds of power plants as the consulting engineer, for the reason that he does not change jobs so often. I believe, however, that it is advisable for operating engineers to specialize in some particular line as, for instance, factory work, electrical-power work, hotel work or whatever may be his choice. Then, let him study it faithfully, every phase of it, until he becomes a master of his specialty. Having done so, I believe that no man on earth could be more competent to lay out plans in his line of business than he.

C. F. Clark.

Hartwick, N. Y.

Fusing Temperature of Ash

The article on "The Fusing Temperatures of Ash," by Messrs. Bailey and Calkins in the issue of November 8, deals with a subject which is for many plants a vital one in the selection of a fuel. Many coals which would otherwise be entirely satisfactory both from the point of heat value and from the point of price, give results which are an absolute failure from an operating point of view when they form clinkers to such an extent that it is entirely impractical to continue their use.

I have seen many tests made with coals of this nature. While these coals would give the lowest cost for evaporation, on account of the complaints of the firemen it was much more agreeable to have a little higher cost and save the excessive hard work. I have never found that a clinkering coal can be burned successfully on the flat grates which we use, which are of the shaker type. As they are of large area (80 square feet), they are difficult to clean and costly as well, for there is always a considerable drop in steam pressure when the doors are opened at time of cleaning.

Apparently, when it becomes necessary to burn a clinkering coal, it is necessary to turn to some of the mechanical stokers for relief. A chain-grate stoker will afford this relief very readily, for all clinkers and ash are continually carried to the pit and dumped and there is no clinker remaining to impede the air flow when fresh fuel is applied. The gravity-feed stokers usually clog more readily and if the clinker is of low fusing point it is apt to run down on the bars and stick. It is probable that stokers will be the salvation of many plants which are at the present time hand fired, when the availability of coal with good nonclinkering qualities is lessened, due to the exhaustion of many of the present seams.

At times when we have had in coal for test that clinkered badly, we have attempted to avoid this by mixing this coal with other coal and while it does lessen the trouble in many cases to just that extent to which the bad coal is diluted with good coal, yet we have noticed cases where adding a coal which only formed medium clinkers to one which formed no clinkers would effect a combination making very bad clinkers. This seems to be due to the fact that the nonclinkering coal had a very high fusing point of ash and the ash as fused into clinkers only formed into small nubs which could easily be shaken through the grates. On adding the coal which clinkered slightly, an element was introduced which had a low fusing point, the result being that the low fusing point ash flowed around the small lumps of the infusible clinker and ran it all together into one large mass. It seems that mixing a coal will never prove to be a remedy and, although this subject has been taken up with a number of different authorities, their opinions have always been to the effect that it is impossible to eliminate clinkers by mixing the coal. If lime, silica or some other ingredient could be added to a clinkering coal and entirely eliminate this trouble it would be a godsend to the engineer suffering from such a trouble, but nothing of this kind seems ever to have been discovered, although we have no doubt but that some New York cobbler may yet discover an alum wash or some other fake which he will sell as suitable for this purpose.

Referring to the point, which is so well expressed, that the percentage of sulphur was no indication of the clinkering tendency of a coal, we have also found this to be a fact, although it seems strange that it should be so, for the greater per cent. of sulphur in coal is combined in the form of pyrites, and the iron in pyrites would be just the material to form a hard clinker. Notwithstanding this point, it seems very inconsistent to claim that there is any intimate connection between the presence of sulphur and clinkering properties.

Within two years, tests have been conducted on over fifty coals and from these

we have selected a number of samples, showing the analysis and giving the extreme range in sulphur contents and clinkering properties. Unfortunately, these tests were not conducted in such a thorough manner that a record was kept of the actual percentage of clinkers; the only record kept being whether or not they did clinker when fired in actual use.

In the table there is one item in regard to clinkers that must be explained. Here, when we express the fact that there are no clinkers, we mean that there are none which will not pass through rocking grates which open to 1½-inch clearance when shaken, and this means that the clinker can be removed without slicing the fire.

COAL CHARACTERISTICS.

Coal.	Coal Field.	Heat Value.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Character of Ash.
Pocahontas, nut	W. Va.	14,700	19.63	74.06	6.31	0.63	Clinkering iron ash.
Steam, R.O.M.	W. Va.	12,400	32.88	50.58	16.58	0.60	Medium quantity of clinkers.
Cabin Creek, N. P. & S.	W. Va.	13,406	33.67	56.01	10.32	0.82	Clinkers very badly.
Queen, N. P. & S.	W. Va.	12,440	32.77	52.47	14.76	1.09	No clinkers.
Pocahontas, R.O.M.	W. Va.	14,198	22.34	69.71	7.95	1.22	Ash heavy and some clinkers.
Jackson, N. & S.	Ohio.	12,149	27.83	56.75	15.42	1.62	Abundant ash, no clinkers.
Lookout, N. P. & S.	Ky.	12,526	33.69	54.73	11.58	1.55	Light-weight ash, no clinkers.
Blue Gem, N. P. & S.	W. Va.	11,282	30.73	46.81	22.46	1.47	Heavy, hard clinkers.
Franklin County, N. P. & S.	Ill.	12,065	33.66	51.51	11.84	2.08	Ash heavy, clinkers very badly.
Glen Alum, N. P. & S.	W. Va.	13,340	35.66	54.68	9.66	2.09	Light red ash, no clinkers.
Gas coal, R.O.M.	W. Va.	15,200	34.54	55.18	10.28	2.68	No clinkers.
Iroquois, N. P. & S.	W. Va.	14,100	34.95	57.46	7.65	2.90	No clinkers.
Sullivan County, N. P. & S.	Ind.	11,162	39.53	44.75	17.72	3.01	Heavy ash, and few hard clinkers.
Nut, P. & S.	W. Va.	11,527	33.65	57.09	9.26	3.44	Light white ash, no clinkers.
Staunton, washed nut	Ill.	12,600	41.72	48.06	10.22	3.16	Heavy ash and no clinkers.
Gaylord, R.O.M.	Ohio.	13,100	38.19	48.54	13.27	3.82	No clinkers.
South Illinois, N. P. & S.	Ill.	11,440	35.22	49.38	15.40	3.88	Ash, slag and clinkers very heavy.

The examples mentioned in this table have been selected from a long list of test coals and it has been done with the intention of showing how little connection there is between the sulphur contents and the clinkering tendency. It will be noted that with a very low sulphur content and a low percentage of ash, clinkers were obtained and also that with a very heavy ash and high percentage of sulphur, no clinkers were obtained. It, therefore, appears that the only possible way to determine the percentage of clinkers in an ash is by obtaining its fusing temperature and knowing the temperature of the furnace; but as few are in a position to obtain data of this kind, it is reasonable to suppose that sole reliance in matters of this kind must be based upon tests actually conducted with the boiler.

J. V. HUNTER.

Fort Wayne, Ind.

Uncle Pegleg on Velocity

Uncle Pegleg's explanation of the problem of the pitched ball, printed in the December 20 issue, is excellent—mathematically. It is evident that all the pitcher really does is to impart *relative* motion and energy to the ball. Probably all the readers of POWER realized the natural fact promptly.

Now, Uncle Pegleg has reconciled his equation based upon this relative motion between pitcher and ball with the same equation applied to the rotative motion of the earth. But, is the same equation applicable in both cases?

When the pitcher throws the ball he imparts a *forward* motion to the ball and —assuming the earth to be previously at rest—a *backward* motion to the earth. It is because the pitcher, with his muscular force, gets in *between* the ball and the earth, pushing one in one direction with his hand and the other in the opposite direction with his feet, that he develops energy. This energy is embodied in the relative motion between ball and earth.

Now comes Uncle Pegleg and says, following the tenets of orthodox mathematical mechanics, that since the earth is also imbued with a motion of its own, twenty-five times as great as that of the ball relatively to it and in the line of the ball's motion, the ball must receive and the earth must impart

$$2 \times 25 = 50$$

times the pitcher's energy. The question is: Is this true to nature? Is this mathematical computation a natural parallel with the other, although the same equation was used?

When we ascribe a velocity of 1500 feet per second to the earth's surface, what do we mean? What is this velocity measured from? From a purely imaginary, massless, geometric line drawn from the center of the earth to—to—to what? It cannot be the center of the sun; for the sun itself moves, enough so that we should lose in a year some 85,000 times 1500 feet. If the "fixed" stars are to be relied upon, which one shall we chose? For they, too, are all in motion.

Of course, in practical astronomy an average of these stellar motions is struck which is amply accurate for all purposes. The reason for raising this objection is to make clear that the earth's rotative motion is one relative to something quite intangible, massless and indefinite—something which the pitcher could not push against hard enough to develop a particle of energy. It is a motion of the very greatest importance in the kinematics of astronomy. It is one which has no part whatever in problems of mechanics and energetics.

If the force developed by the pitcher had acted or reacted upon any mass which was stationary relative to the heavens, then it would have been proper to compute energy by using this force and the earth's motion. Should some comet happen along and wipe off a portion of the earth's crust, as one did in Jules Verne's "Meridiana," then the rotative velocity of the earth, not relative to the sun, or to the fixed stars, but to the comet, would be a very real thing, and positive or negative energies computed upon it would have a very real existence. But, as it is, the introduction into a problem of an imaginary, mathematical fund of energy, based upon a massless geometric motion, is wrong and misleading. The mere fact that careful mathematics will bring in an equal fund of imaginary, geometric energy on the other side of the equation, making the problem "come out" all right, as Uncle Pegleg has skilfully shown, makes it only the more misleading, because it looks so accurate.

The fundamental rule in mechanics which is sought to be impressed is that no *force*, no *velocity* and no *energy* may ever be introduced into a problem in energetics, unless they exist *between two masses*. In studies of pure motion, such as problems of gear teeth, valve gears or astronomical orbits, it is proper to mention velocities without their massive sources. In studies of pure force, as in parallelograms of force, it is proper to mention forces without their massive sources. But while this is being done the student should be frequently reminded that neither force nor motion can exist except *between masses;* for the present lax methods have led to a very widespread idea, prevailing sometimes with very high authorities, that force and motion can and do exist otherwise than *between* two or more masses—which is a fundamental error. In the study of energy neither force, motion nor energy should ever be mentioned as divorced from mass at both ends.

S. A. REEVE.

New York City.

Boiler Explosion at Weatherly, Penn.

A lap seam of a return tubular boiler failed due to an old crack that extended about two thirds the length of the sheet and over half way through the plate. The explosion killed two men.

The silk mill of the Reed & Lovatt Manufacturing Company, Weatherly, Penn., was the scene of a disastrous boiler explosion on December 12 shortly after the plant had been shut down for the day's run, when one of a nest of five boilers exploded, instantly killing two men.

According to the clock in the engine room, which was stopped, the explosion occurred at 6:08 p.m., after most of the five hundred operators in the mill had left for the day, and this undoubtedly reduced the death toll, as many of them just before the closing hour had been in the habit of congregating directly back of the boiler room, which was partitioned from the factory by an 18-inch brick wall. Had the boiler exploded ten minutes earier, many of the workmen would have undoubtedly been killed.

The five boilers in this section of the steam plant were made by Samuel Smith & Son Company, and the boiler that exploded was located in the center of the nest. It is stated on good authority that this is the first boiler that the makers have lost due to an explosion.

The force of the explosion entirely wrecked the boiler house, and knocked down a section of the 18-inch brick wall between the boilers and the mill. The side of the engine room next to the boiler was demolished, and the engine room was partly filled with brick and wreckage. From the violence of the explosion it is evident that the boiler was full of water at the time, although there is the usual talk of low water as the probable cause.

The day fireman had left after being relieved by the night fireman, Richard Beers, who was killed, as was also Michael Moony, the chief engineer. Beers was found dead under a pile of brick at the rear of the boilers, close to the feed pump. Moony was found dead under a heap of brick and timbers at the door leading from the engine room into the boiler room. He was dressed ready for going home and was evidently only waiting for the return of Beers to announce that his end was shut down and bid him good night. Both men were badly scalded and bruished.

Two of the boiler settings were entirely demolished, and two boilers were left on badly wrecked settings. A general view of the wrecked boiler house is shown in Fig. 1. The hole in the wall is directly in front of the place where the mill operatives congregated waiting for the whistle. The force of the explosion was up and sidewise, toward the two boilers next to the engine room.

Details concerning the boiler that exploded are as follows: It was put in place in 1888 and has been in service 22 years. It was a longitudinal return-tubular boiler 16 feet long and 66 inches in diameter. The plates were of 3/8-inch steel, but the tensile strength is not known as no stamp could be found. Both heads were made of 9/16-inch stock, and the rear head was braced by twelve 7/8-inch round crow-foot braces above the tubes and four braces of the same type and size below the tubes. The front head was strengthened by twelve braces above the tubes of the same size and spacing as those used on the rear head, but there was no bracing below the tubes in the front end of the boiler, as the manhole was reinforced. The other four boilers were all braced in the same manner and were of the same construction.

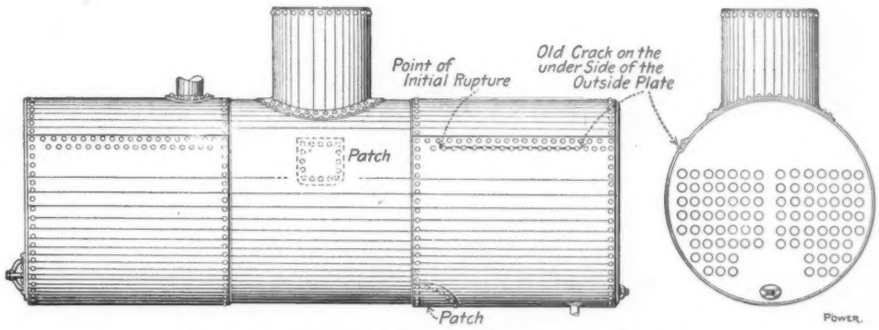


FIG. 2. SHOWING LOCATION OF CRACK AND PATCHES

FIG. 1. VIEW OF THE WRECKED BOILER HOUSE. BACK OF THE HOLE IN THE WALL IS WHERE THE OPERATIVES WERE ASSEMBLED TEN MINUTES BEFORE THE BOILER EXPLODED

A 36-inch dome was attached to the boiler. It had a cast-iron head 1 1/16 inches thick that was reinforced by a rib 3 inches deep and 1 1/8 inches wide, cast on the inner side. The flat surface of the head was not braced, although the dome was stayed to the boiler sheet

by six ⅞-inch braces. All of the five return-tubular boilers in this section of the plant were equipped with a dome of similar construction.

With two exceptions the braces between the heads and the sheets held, the rivets in all the others being sheared where the braces parted from the plate.

The explosion was directly due to an old crack that extended from one-half to two-thirds through the plate in line with the second longitudinal row of rivets of the rear sheet. This crack was on the under side of the outer plate and was of such a character as to escape attention by the boiler inspector who examined the boiler on May 30 of this year. It extended from a point about twelve inches from the girth seam nearly to the rear head. This plate was considerably thinner at the inner end of the longitudinal joint seam than at the outer end and it was at this point that the initial rupture occurred, as indicated in Fig. 2. This sheet also had a patch 15 inches long by 24 inches wide located on the bottom of the plate. There was also a dry patch on the second sheet of the same boiler, as shown by the dotted line in Fig. 2.

After tearing along the lap-joint seam through the rivet holes, none of the rivets giving way at this joint, the sheet opened up one-half of the diameter of the shell, as shown in Fig. 3, the rivets shearing in practically every instance at both the head and girth seams. Many of the rivets indicated that the holes had not been in line when the boiler was constructed, but whether this is so or the ogee appearance of the rivet was the result of the plates being stripped from the others, is difficult to determine. In places the plate showed slight signs of brittleness and several cracks were visible around the rivet holes, which were of 2½-inch pitch. There was no scale to speak of in the boiler, either on the shell or tubes.

The force of the explosion blew the rear head and attached plate a few feet back from its original setting, every tube pulling out of this tube sheet. The other two sheets, front head and tubes were blown several hundred feet into the woods back of the plant, mowing down the trees that happened to be in their path.

Although several bad dents appear in the sheets and head of this section of the boiler, due to striking rocks in their flight, the plates do not show signs of fracture.

Many of the ninety-six 3-inch tubes were worn very thin, especially at the end that pulled out of the rear head, and a number of the lower tubes were badly pitted. The pressure carried on the boiler was usually between 85 and 90 pounds per square inch. A pop-safety valve that has not been found at the present writing was fitted to the boiler. All of the boilers were under steam at the time of the explosion and were connected to the same steam header. The boiler was insured by the Hartford Steam Boiler Inspection and Insurance Company.

The foregoing data and the accompanying photographs were obtained through the courtesy of Raymond Thorp, agent of the mill.

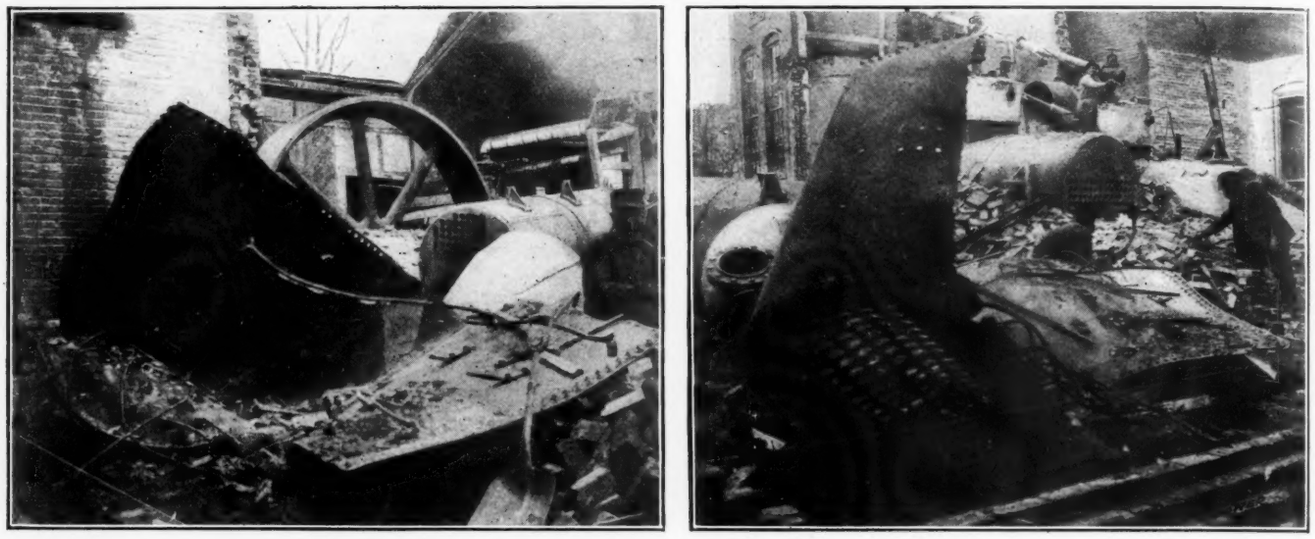


FIG. 3. TWO VIEWS OF THE REAR HEAD AND FRACTURED SHEET

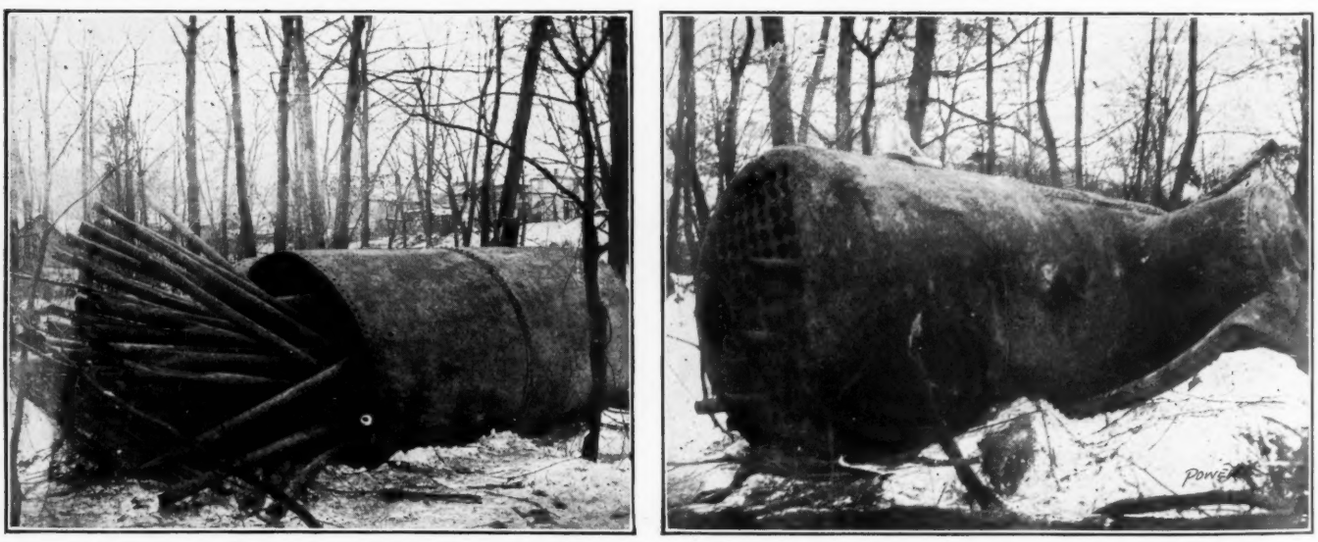


FIG. 4. VIEWS OF MAIN SECTIONS OF EXPLODED BOILER

Notes on Power Station Economy*

By H. P. Wood

In discussing the economical operation of a 30,000-kilowatt turbine power plant the author shows the importance of apparently small items which in the aggregate make for either great economy or great waste.

It is the purpose of this paper to give members of our section an idea of the various things which enter into the economical operation of the Gold street power station.

Fuel

The present cost of fuel and its continual rise in price give a constant struggle with the problem of fuel economy. This item in a properly designed and conducted plant should amount to three-quarters of the total cost per kilowatt. The Gold street plant contains no complications or intricate devices and is so arranged that by careful operation very economical results can be obtained.

Starting with the boiler room, there are a number of factors which must be closely studied. First one among them is the burning of the fuel, consisting of a mixture of four parts No. 3 buckwheat and one of bituminous coal, which experience has demonstrated is the best suited to the conditions. This mixture is burned at times at the rate of 26.6 pounds per square foot of grate per hour, giving a furnace temperature around 2700 degrees which, though satisfactory as to evaporation, is hard on the furnace walls and arches.

Upkeep

Another important point to be considered is the keeping of the boiler clean, both the inside and outside of the tubes and drums. The sulphur from the coal burning on the outside of the tubes and drums requires that they be cleaned daily by blowing with a steam jet. Though expensive, the cost of this blowing is small compared with the expense necessary to keep them clean on the inside. The boilers are blown down daily, and once in three weeks are emptied and filled with water from the condensers. If scale is found 1/32 inch or more in thickness, a cleaner is used to remove it. The seven lower rows of tubes are usually cleaned every six months and the others once a year.

Feed Water

The feed water contains 1.8 grains of scale-forming matter per gallon, which means that the eleven and one-half million gallons of water evaporated deposit 1.3 tons of scale per year in each boiler which must be taken care of if any degree of economy is desired.

It is necessary to keep down the amount of air which passes through the fire. If any holes are allowed in the fire, or air leaks in around the brickwork, it is quite possible to lose 25 per cent. This is one of the easy things to keep track of, a CO_2 gas recorder constantly keeping a record.

Then comes the flue temperature, which should run from 500 to 600 degrees. A temperature above or below this means that one of several things has gone wrong. In case it has gone up, probably the tube brick in the baffle walls has come down; if it goes down, it usually means that the setting is leaking, or the fireman is not keeping his fires properly covered.

And next comes the question of superheat. There is approximately a gain of 1 per cent. for each 12 degrees that the steam is superheated.

Standby Losses

In the commercial operation of a plant under varying load conditions, such as are met with in our system, it is necessary to maintain steam pressure on boilers which would otherwise be idle, in order to provide sufficient reserve capacity. This represents 6.6 per cent. of the fuel burned. This requires fuel, though not adding in any degree to the output.

It seems astonishing that twenty boilers are used during the peak and only ten the rest of the time; that eleven boilers would give the same output if the load was constant.

The proportion of standby loss depends upon the load factor, duration of the peak, number of units, design, construction and methods of operation.

The temperature of the air going to the fires has a marked influence on the operating costs, a reduction of 2.7 per cent. in the amount of coal being made by a change in the location of the blowers by which warmer air was secured than formerly.

Feed Water

The next important item to be looked after is the feed-water system. There was originally installed a closed-heater system. With this we were unable to maintain a temperature of more than 170 to 180 degrees, with the loss of approximately 12 per cent. of the total returned auxiliary steam. It was decided to install the low-pressure or open-type heater. The hotwell water from the condensers and the necessary makeup water are supplied directly to the open heater, from which it is pumped into the feed-water mains by four-stage centrifugal pumps. The saving of the exhaust steam was one of the factors which decided the installation of turbine-driven auxiliaries.

Coal and Ash Handling

In the coal-handling system there is little to be saved. But by the equipment of one of the two towers with a one-man control system it is expected to reduce the cost of coal handling about 14.5 per cent.

Experiment has proved that two laborers can keep a large section of the ash cellar clean, which leaves practically little chance to make any marked saving, as the installation of an elaborate system of ash-handling apparatus would increase the upkeep more than the cost of labor saved.

Turbine Equipment

There are in the plant four turbines, totaling a capacity of 35,000 kilowatts, based on the highest temperature at which they will operate continuously.

The day load runs from 12,000 to 14,000 kilowatts, which divides up very nicely. The night load is much less. If our units were divided so as to give a full load for two small or one large one, we would be able to save 5.7 per cent. of the present operation cost. This cannot be determined exactly, owing to the annual increase in the load. While the present units do not divide nearly so well as they might, in one or two years from now they will be right. Then, again, in one or two years more we will be back to the same conditions which face us at the present time.

With the present load factor, it requires two units for the ordinary day load, and three for the peak. After careful tests the most economical point of operation has been determined, and when the load will allow it, the turbines are run at that point, except during the peak. When two turbines are operating at approximately full load, the third turbine is kept hot and the auxiliaries running so that it may be brought up to speed and put on the line. By this method we save 5.6 per cent. over the former method of operation, which was to run three turbines when there was a load for two.

Vacuum

Another important item is vacuum. This required constant vigilance and the average vacuum is not what we hope to obtain. The loss of 1 inch of vacuum on one of the larger units means $14,700 per year. This item is of such importance that it

*Abstract of a paper presented at the December meeting of the Brooklyn section of the National Electric Light Association.

calls for a great deal of time and consideration.

Condenser Tubes

There has been a great deal of annoyance and expense resulting from the failure of condenser tubes. If all of the tubes could be kept tight so that all of the condensation could be returned to the boilers, $28,000 per year would be saved. In only one condenser have the tubes been tight for any reasonable length of time. In this one they have given satisfactory service for four years, only 12 tubes having to be replaced.

It is not possible to understand why they should stand in one condenser and fail in all of the others.

There are two losses which occur in handling the circulating water: one, the amount of steam required to pump an unnecessary amount of water; the other, the lowering of the hotwell temperature.

From experiments it has been found that where the temperature should be 100 degrees at 28 inches of vacuum, it is often found to be 85. This represents 15 B.t.u. lost in each pound of water, or for a year, 1630 tons of coal.

Discussion

Mr. Pope, referring to a curve showing the total kilowatt-hours, said that makes 1131 electrical horsepower output for each boiler, where the rating is 730.

This looks like perpetual motion to me, and I would like to have it explained—1131 horsepower output from a rating of 730 horsepower.

Mr. Buxton: We are greatly indebted to our operating engineer for the clear and concise exposition he has given us. It covers the ground, instructs, entertains and is of permanent value. It is worthy of wide distribution.

Mr. Helwig: It is only within the last few years that operating engineers have come to the conclusion that if there was any economy to be obtained in the operation of a station, it is in the boiler room. Not so many years ago the losses of the boiler room amounted to 30 to 35 per cent., while the losses now reach about 25 per cent. at the most. The boiler efficiency has increased from about 55 per cent. to 65 per cent. in regular station operation.

The losses were decreased by keeping tab on the flue gases both temperature and per cent. of CO_2, and sampling ashes for unconsumed coal. The loss up the flue, due to temperature, varies directly as the temperature of the gases, and may be caused by poor bridgewalls, defective baffles, tubes dirty internally and externally, or bad setting and bad firing, high flue temperature indicating bad baffles and bridgewalls, and low temperature, leaky settings and bad firing. The percentage of CO_2 is an indication of the efficiency of the furnace. About 4 per cent. CO_2 will mean a loss of 42 per cent. up the stack, and 14 per cent. CO_2 means 12.5 per cent. loss up the stack. The average per cent. of CO_2 for daily operation is between 10 and 12 per cent. at the present. Years ago 7 to 9 per cent. was considered as a fair result. The maximum CO_2 obtainable for perfect combustion is 20.8 per cent., which means using all the oxygen in the air. The percentage of CO_2, where the boiler is in good shape, depends entirely upon the fireman. If he permits his fire to get full of holes he reduces the CO_2 and the initial temperature. As high as 17 per cent. of CO_2 has been obtained by choking off the flue damper and air supply and firing light, but in doing this the capacity of the boiler was cut down. Good, high furnace temperature was obtained, but at a loss of capacity. The best results are obtained with an excess of air of about 100 to 120 per cent. Fuel losses in refuse, which used to be about 14 per cent., are now reduced to from 5 to 8 per cent., due to more careful firing and closer study of the grate problem.

Another point that may be brought out is that the ratio of the heating surface to grate area has been reduced from about 90 square feet of heating surface to 1 square foot of grate to about 45 square feet of heating surface, and in some cases as low as 40 feet, in some of the stations around New York.

Mr. McGee: It is stated that a furnace temperature of about 2700 degrees Fahrenheit was obtained. At what part in the furnace was this? Is it possible to get a higher furnace temperature with the present methods of firing? If it is possible to get a higher temperature, will the air circulate fast enough to prevent burning or blistering the tubes? Can furnace walls and arches be built that will not melt at the higher temperature? The present temperature destroys the furnace brickwork very rapidly.

Will the circulation in the superheater be rapid enough to maintain 100 degrees superheat without raising the pressure?

Professor Maxwell: I could give you some few personal experiences which bear immediately upon the questions brought out in this paper. About five years ago I was called upon to investigate the reason why four large tubular boilers would not supply sufficient steam to operate a plant successfully. In the boilers soft coal was piled into the furnace right up underneath the tubes, making a thickness of fire of from 20 to 30 inches. Experience, years before, had taught me the value of fires as thin as can be carried. I cut the fires down to about 10 or 12 inches. The result was, during a 24-hour test, they had all the steam they wanted.

Upon one occasion I performed a series of tests for the Navy department to demonstrate the loss of economy due to forcing a boiler. Under natural-draft conditions for every pound of coal burned nine pounds of water were evaporated. Under forced draft 60 pounds of coal were burned per square foot of grate, and the evaporation dropped to 6½ pounds of water per pound of coal.

The temperature of the flue should be between 500 and 600 degrees.

Two years ago I was called to test four boilers, guaranteed 70 per cent. efficiency. I ran preliminary tests before the final. I found the temperature of the flue gases was 850 degrees. On the second preliminary test 65 per cent. efficiency was obtained, and the temperature of the flue gases dropped to a trifle under 600 degrees.

The guarantee required 10½ pounds of water to be evaporated per pound of coal from and at 212 degrees. I determined to use 0.28-inch draft and put a differential draft gage in the ashpit of each of those boilers, marked the furnaces with chalk and gave instructions that no fireman should open a door or fire without orders. The draft gages were watched very carefully, and the instant that one gage dropped one-hundredth of an inch, it would signify that the fire had burned a hole in the coal bed. The fireman would open the door and would see a black spot in the fire, on which he would put one or two shovels of coal, just enough to cover the spot. In that way the minimum amount of coal that the grates would burn to give the evaporation was found. That was an unusual condition but made an efficiency of 85 per cent. in an eight-hour test.

In the turbine station at Gold street, I think the pressure is 180 pounds, and the temperature corresponding to that pressure would be about 380 degrees. Well, for 100 degrees superheat, it would be 480 degrees.

Mr. Johnson: There is one point in Mr. Wood's paper that fits in with my own experience so well that I could not help thinking about it all the time, and that is the matter of condenser-tube corrosion. Mr. Wood had one condenser run four years without giving any trouble, and others in which the tubes were constantly failing. My experience was just exactly the other way. In seven condensers I had only one that gave trouble; the others never bothered.

At the time we were having the most trouble, there was a great deal of talk about electrolysis, and the electrical department was blamed. We said that there were grounds or stray currents, or something that came into that condenser, or rather the tubes, with the water, and went away with it, and when the current left it took some of the tube with it.

They said that there were no grounds inside of the station, and several other things. The assistant engineer came to me one day and said, "I want to put up

a job on the 'super.'" I said, "What is it?" He replied, "Well, I want something to be the matter with No. 5 for a week." "All right," I said. So he reported that we were waiting for some little detail; that the engine could be run, if it was absolutely necessary, but wanted to have the other units in the plant used if possible. For an entire week No. 5 auxiliaries were run, and then the condenser was opened, tested and found to be in perfect condition. The imaginary parts had not arrived; and at the end of another week everything was apparently all right. The imaginary repairs were completed, and the engine was reported to be in good order. It was started in. In four days there were two tubes down. They were put in, and more imaginary repairs were put on the engine. For two weeks the pumps were run, and there was absolutely no sign of any decay anywhere. The load was put on the engine again, and in less than a week we had to put in more tubes, and that thing continued for two or three years; and I want to say to Mr. Wood that I believe he should accuse the electricians and put the blame for the deterioration on them.

Mr. Kemble: I have not checked Mr. Pope's figures but if I may draw from my own experience for a moment, I will say that in Boston we had two pair of 500-horsepower boilers, a little old style—in fact, considerably older than those at the Gold street station. Five hundred horsepower requires the evaporation of 15,000 pounds of water per hour. There having been a little bit of discussion between the master mechanic and me as to what those boilers were actually doing, we tried out some tests, and found that regularly during the peak loads those boilers, which were supposed to evaporate 15,000 pounds of water per hour, were evaporating from 22,000 to 24,000 pounds, over 50 per cent. overload. I am a little inclined to think that the discrepancy between 730 boiler horsepower and 1130 electrical horsepower is simply due to the elasticity of the boiler rating.

As regards what Mr. Buxton said, I know that Mr. Wood, in writing it, attempted particularly to make it interesting to the nontechnical or semi-technical members of the section.

In regard to the remarks of Mr. Helwig, it is possible to increase the CO_2 as he mentions by shutting down on your furnace until you get a maximum percentage of CO_2 but have no capacity. It is also possible to increase your CO_2 remarkably, and a trick practised sometimes by firemen seeking a record is to close down on your air supply, raising your CO_2 percentage, but sending a large proportion of unburned gases up the stack. So the CO_2 percentage cannot be taken as an arbitrary value of the boiler, unless checked up by some other method.

Mr. McGee brings up the question of higher temperatures. That depends somewhat on the point of location of combustion. An extreme case would be if you had the combustion all on one point.

No material would stand the temperature. Now, by a proper proportioning of furnace, combustion can be spread over the whole area without abnormally high temperature at any one point.

As to Mr. McGee's question about the circulation, I would say that boilers similar in type to those in the Gold street station have been forced up to 40 pounds of coal per square foot of grate, which means an increased output, without trouble from the formation of steam pockets or blistering of the tubes. As regards the superheat, 100 degrees, or even as experimentally tried, 180 degrees, does not seem to produce undue deterioration of the superheater, providing there is not too much sulphur or other impurities in the coal.

Regarding Professor Maxwell's remarks as to evaporation, it may be of interest to know that some of the new boilers which are being furnished for new warships are furnished on a guarantee of 11½ pounds of water evaporation per pound of combustible, with 2 inches of air pressure under the grates.

I was very much interested in his account of the beating of the specifications. It reminds me of that little story about a fellow who wanted to get into the navy, wanted to get into Annapolis, and was about three-sixteenths of an inch short; and so he went out and got one of his friends to swat him on the head with a club, and the bump passed him.

Perhaps in illustration of the method of figuring out very closely the results which can be obtained in practice I might mention the old navy trial-trip method of reporting the horsepower developed to four or five places of decimals, and the speed obtained by the ship to six places of decimals, when the probability was that if they came within 75 or 100 horsepower they were doing very close work. I could not help thinking, when he was speaking of the 85 per cent. efficiency, whether if the contractors had been offered a little bonus, he could not have done better than that.

As to his question of numbering the furnace doors, the practice was started in England, if I remember rightly, in 1889, the practice of time firing in the trials, and it was first put into practice in this country in the trials of two Russian warships, which were built by Cramps, and tried in 1899 and 1900. I had the fun of training the firemen for these trials. The engineer's department decided how much coal had to be burned under each boiler to produce the volume of steam which would produce a given speed of the ship, and clocks were set in each fire room, with speed buttons placed around the circumference of the clock similar to those clocks in a billiard room—if any of you gentlemen go to such places—where they could move them around and get an electric contact every so many minutes to ring a bell. On receipt of orders from the engine room that such a speed was to be made, the clocks were set so as to ring a bell every so many seconds or minutes, as the case was, depending on whether the speed was high or low. When the engine-room artificer ordered certain doors—they were opened, and so many shovelfuls of coal were spread on the fire. In the preliminary trials, while checking up the engineering department's calculations it was only found necessary to change one rating, and the speeds were carried through by that time firing system; and not only that, but the standardization trials, which consist of a series of runs at different speeds, were all carried through on that prearranged coal consumption; so, when a certain speed was wanted, the engineer did not open the throttle and yell for more steam; he simply notified the boiler rooms, and the boiler room provided the steam.

In regard to the remarks made by Mr. Johnson, I have no doubt—and I could not help wondering all the time if he had a piece of wood in his pocket which he touched when he spoke of having only one condenser trouble out of seven. Certainly the scheme of indicting the other fellow for petit larceny when you lose a tube is worthy of imitation, provided you can convict him. I presume Mr. Wood will be glad to use the method of charging it on to electrolysis, because we don't have any street railway connected on to the line system, and electric-light current, as everybody knows, never does any harm.

It occurred to me that possibly some of these troubles might be due to the presence of air. A ship running to South America could not keep condenser tubes in a trip of about six weeks; it was necessary to retube a portion of the condensers at each end of the trip. The discharge from the air pump was located high in the hotwell, so that a great deal of air was taken in; the water was churned, charged with air, and pumped into the boilers. An elbow with standpipe was put in so that the water was delivered at the bottom of the feedwater tank, so that it did not produce the churning and drawing of air, and the corrosion practically stopped. There are two cases that have come to my attention where trouble has been had with condensers in stationary plants, where the stopping of the leaks in the air circulation by arranging a sheet-piling shield around the intake stopped or materially reduced the corrosion. Possibly the presence of air and its effect in corrosion have not been given sufficient attention.

FIG. 1. BOILER LYING IN ALLEY BETWEEN MILL AND WATER-WORKS SHED JUST AS IT LANDED AFTER EXPLOSION

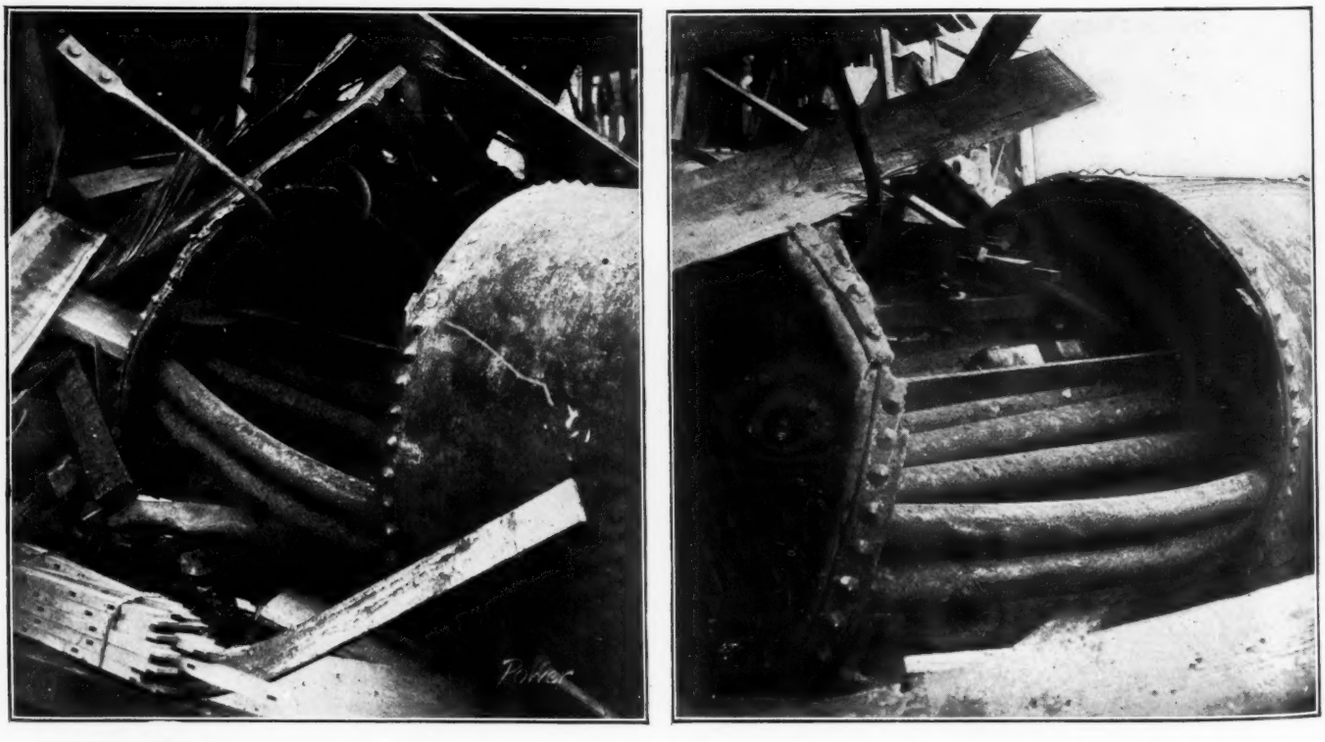


FIG. 2. TWO VIEWS OF THE RUPTURED END, SHOWING HOW THE SHEET WAS TORN THROUGH SOLID METAL

Boiler Explosion in Massachusetts

Another case of lap seam boiler failure. The fifth disastrous explosion in Massachusetts within recent years and second in New Bedford, the others occurring at Fall River, Brockton and Lynn.

Though it is often the unexpected which happens, that which may be reasonably looked for also often occurs. This is exemplified in the fifth disastrous explosion in Massachusetts during recent years of a boiler of lap-seam construction.

At a few minutes past 11 o'clock Friday forenoon, December 9, the 42-inch by 16-foot return-tubular boiler in the planing mill of Arthur S. Allen & Co., North Water street, New Bedford, Mass., exploded, wrecking the building and dangerously, if not fatally, injuring Mr. Allen, and painfully scalding, bruising and cutting six of the ten employed in the mill at the time.

The boiler, which was installed in 1885, was of the common double-riveted lap-seam type, built in five courses with three supporting lugs on each side one in the middle of the alternate courses, the first, third and fifth course.

The sheets were 5/16 inch thick with 11/16-inch rivets with a pitch in the longitudinal seam, which with a rivet strength equal to the proportion of the plate uncut by rivet holes would give with a factor of safety of six a working pressure of 75 pounds per square inch. The tubes, 38 in number, were 3 inches in diameter and in good condition, clean and free from laminations or other defects.

FIG. 3. RUPTURED SHEET AS IT LANDED

But one sheet, that making the rear course, was torn; not a rivet was sheared and but one pulled through. This was where the rear head cracked as the sheet was torn like wet paper away from the head and the course in front. It is plain that the initial rupture occurred at the side of the outside lap, close to the row of rivet heads.

There is no evidence that the boiler had anything but good and intelligent care. Two or three minutes before the explosion the fireman noticed that the steam gage registered between 60 and 65 pounds pressure and was probably correct, as the boiler had been inspected about three weeks previously. No investigation by the proper authorities has yet been made, and, so far as can be learned, no steps have been taken to fix the responsibility for the accident. There is a newspaper story to the effect that Mr. Allen had been notified by the inspector of the company by which the boiler was insured that it was unsafe and that a new one should be installed or the working pressure reduced. Mr. Allen's reply to this warning was the transfer of his insurance to another company.

It is unfortunate, if this story be true, that the specific section of Acts of 1908 of the General Court of the Commonwealth of Massachusetts, referring to this particular action on the part of a boiler owner, did not become a part of the law in the beginning.

Central Station Insurance

At the St. Louis meeting of the National Electric Light Association, statistics were presented by W. H. Blood, Jr., insurance expert of the association, tending to show that fire-insurance premiums paid by the electric-lighting companies of the country are fully twice as high as the low ratio of loss would warrant. Resolutions were adopted by the association asking for an investigation of the subject by the fire-insurance companies and directing that copies of the resolution be furnished to member operating companies so that they might take up the matter with their brokers. A thorough campaign along these lines has recently been organized as fitting at this season of the year, and large numbers of copies of the resolution have been placed in the hands of the operating companies, requesting them to bring the matter to the attention of their insurance brokers. Letters have also been written from association headquarters to some 250 insurance companies, calling their attention to the matter and inviting them to investigate the subject with a view to a reduction in rates commensurate with the premiums received and the risks involved. An extremely interesting report and analysis of the subject generally was presented at St. Louis by Mr. Blood and has been reprinted in the annual proceedings of the association.

Undoubtedly, states the *Scientific American*, the most troublesome parts of electric generating machinery are the armatures and rotors. Insurance records for 1909 placed the armature and rotor difficulties at 40 per cent., and commutator and slip-ring troubles at 29 per cent. In direct-current motors 39 per cent. of the failures were due to the armatures and 31 per cent. to the commutators, while in alternating-current motors rotor defects amounted to 23 per cent., and slip-ring and commutator troubles to 6 per cent., and 49 per cent. of the defects originated in the stator coils.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it.

Area and Mean Effective Pressure

How is the mean effective pressure in the cylinder found from an indicator diagram after the area has been found with a planimeter?

A. M. P.

If the area of the diagram is divided by its length, the quotient will be its average hight, and this multiplied by the scale of the spring will be the mean effective pressure.

Water for Condensing Engine

A condensing engine requires 800 cubic feet of water to be fed to the boilers in a day. What will be the quantity of water needed in a jet condenser to condense the steam?

W. C. E.

It will depend on the temperature of the exhaust steam and of the injection water. Seventeen pounds of water for each pound of steam condensed will be sufficient under average conditions, but it should be possible to furnish thirty in an emergency.

Weight of Bituminous Coal

What is the weight of a cubic foot of soft coal and how many cubic feet in a ton?

W. B. C.

Its weight varies from 50 to 55 pounds per cubic foot. Forty cubic feet of bunker space is usually allowed per ton.

Safe Receiver Pressure

With a triple-expansion engine, how is the safe receiver pressure determined?

S. R. P.

The receivers of most, if not all, engines where the cutoff is subject to hand regulation are provided with safety valves set by the builder at a point of release which will prevent a dangerous pressure.

Reducing Diameter of Eccentric

If ¼ inch is turned off an eccentric, would it alter the travel of the valve?

R. D. E.

It would not.

Rollins Engine Valves

What kind of valves has the Rollins engine?

R. E. V.

The steam valves are multi-ported grid and the exhaust are double-ported valves of the Corliss type.

Water Disappears from Gage Glass

With the gage glass half full of water, the blowoff cock and all other connections to the boiler tight, the fire was banked so heavily at night that it went out. In the morning there was no water to be seen in the glass. What became of it?

W. D. G.

Such an occurrence is highly improbable. If it did occur it is likely that the heat of the setting evaporated enough water to lower it out of sight and this evaporation was condensed in the steam pipes which the question does not say were shut off from the boiler. This assumes that there was no leak at seams or elsewhere.

Formulas for Pulley Diameters

What are the rules for calculating the revolutions and diameters of pulleys?

F. P. D.

The calculations are simple proportions. In deriving formulas for the various conditions let

D = Diameter of driving pulley;
R = Revolutions per minute of driving pulley;
d = Diameter of driven pulley;
r = Revolutions per minute of driven pulley.

Then

$$D : d : : r : R$$

from which with any three of the factors being given the fourth may be found. To find the size of the driven pulley,

$$\frac{D \times R}{r} = d$$

To find the size of driving pulley,

$$\frac{d \times r}{R} = D$$

To find the revolutions per minute of the driven pulley,

$$\frac{D \times R}{d} = r$$

To find the revolutions per minute of the driving pulley,

$$\frac{d \times r}{D} = R$$

Positive Cutoff Engine

What is a positive cutoff engine?

P. C. E.

It is an engine in which the steam is cut off at the same point in the stroke and the speed is controlled by throttling.

Riding Cutoff

If a riding cutoff valve is set to cut off the steam at one-half stroke on the outward stroke, will it cut off at the same point on the return stroke? If not, what can be done to make it?

R. C. O.

If the valve stem and eccentric rod are of the right length, the cutoff will occur at the same point in both strokes. Corrections may be made by making the rod length right and then turning the eccentric until the cutoff takes place at the right point.

Inside Lead

If a valve is given inside lead, what effect will it have?

I. V. L.

The exhaust will open earlier and close later in the stroke.

Change of Engine Speed

How can the speed of an engine be increased by the governor?

C. E. S.

Slight increase in speed may be obtained by weighting the governor. But if any great change is desired the pulley on the governor shaft must be increased in diameter.

Diameter of Steam and Exhaust Pipes

What proportion should the diameters of the steam and exhaust pipes bear to the cylinder diameter?

D. S. P.

For a piston speed in the neighborhood of 600 feet per minute the diameters should be 0.3 and 0.4 that of the cylinder respectively.

Average and Mean Effective Pressure

What is the difference between the average pressure and the mean effective pressure on a piston?

C. N. D.

The mean effective pressure is the average pressure urging the piston forward minus the back pressure or that tending to hold it back.

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POWER and The Engineer

Editorial

Limit Lap Seam to Ten Years

Reports of the explosion of lap-seam boilers with the attendant casualties, the killing and crippling of men and the destruction of property, follow one another so rapidly that the statement by someone that the barbarities of peace are greater than those of war seems justified. In the suffering caused by the explosion of boilers of lap-seam construction this barbarism is exemplified to a degree unknown in any other line or country other than the United States. It is a matter of common as well as shameful knowledge that license in the design, construction and operation of admittedly dangerous boilers obtains in this country that is tolerated in no other part of the civilized world.

Lap-seam boiler construction is particularly barbarous from the mechanical point of view, which shows that steel resents the treatment necessary to force it into the shapes demanded by this construction.

It is barbarous from the financial viewpoint because every boilermaker knows and every boiler buyer should know that for boilers of equal size and strength the lap-seam type costs more than those with the butt joint.

It is barbarous from the common-sense standpoint to make, install and operate any piece of apparatus, the disastrous failure of which is as inevitable as death.

In fact, it is barbarous from any point of view that may be taken—business, sentiment, history, patriotism and ethics.

The strength of the lap seam is ample for the purpose when new, but that it rapidly weakens with use is too well known to bear discussion, and where boilers with this seam are in use, the miscalled factor of safety should be increased annually to such a degree that will make such a boiler useless for power purposes before it has reached the age of ten years.

Few lap-seam boilers have failed under ten years, though the first one to fail in the Acushnet mill, New Bedford, Mass., in 1897, was but seven years old and the Harney boiler, which exploded in Lynn, Mass., in 1906, had been in use just ten years.

It is probable that eighty per cent. of the boilers in use in this country are of the lap-seam type, the greater proportion of which are well on the road to certain destruction and should be retired by the enactment and enforcing of laws as drastic as are needed for the purpose. Legislation along the lines tending to public safety in the matter of steam-boiler construction and operation is farther advanced in Massachusetts than in any other State, but here the hands of the boiler-inspection department are tied by the stultifying regulation which permits the operation of any boiler on which any insurance company will carry a policy.

In the rules formulated by the Board of Boiler Rules of Massachusetts will be found the factors of safety to be used in calculating the working pressure which may be carried on lap-seam boilers, and it is notorious that this factor is but twenty per cent. higher on a boiler which may have been in use half a century than on one which was installed the day before the boiler rules became operative.

If this board has the power to determine the factor which shall be used, why has it not the power to use common engineering discretion and consider the probable condition of a lap seam which has been distorted thousands of times daily and fix the end of service in Massachusetts at least at not over ten years?

The Right Idea

The recent action of the educational committee of the National Association of Stationary Engineers No. 37, of Ohio, an account of which appears elsewhere in this issue, may be regarded as an advance step toward fulfilling one of the principal objects of such organizations—that of educating its members into becoming more proficient in their present occupations and fitting them for advancement. Heretofore it has been the custom for the State committees to arrange a program of lectures to be given during the season under the auspices of the various local branches; but, as a rule, the initiative has seldom been taken by the local associations themselves.

One great drawback to the custom of merely making advance announcement of the lecture topics has been that the discussions which usually follow such lectures are confined to a comparatively few members, the large majority of those present feeling that they are not sufficiently prepared to enter into a discussion of the topic under consideration, and in this way many valuable suggestions are never brought out. To get the full benefit from any discussion, one should enter into it. Hence, if only a few take part the rest lose interest and the main

object is defeated. In the present instance, however, a list of questions has been compiled and circulated in connection with the announced topics, the questions being of such a nature as to open up new lines of thought and awaken the interest of all members. With such an arrangement many, who would otherwise be backward in expressing their views, are afforded an opportunity to prepare themselves in advance and as a result contribute materially to the value of the discussion. The Dayton local association has the right idea and it is to be hoped that others will follow its example.

Handling Men

Much time and space are taken in discussing the management of equipment, and properly so; but the management of the men who operate the equipment is a matter of no small importance. A crew of dissatisfied, badly managed men can cause severe losses in the best equipped plant, while a well managed crew, through watchfulness and cheerful painstaking, will make the log sheet show up results.

Nearly everyone can point to a plant that the best firemen and engineers shun because of some shortcoming in the management. And who does not know of a plant where, although the work is hard, a position is held desirable because "the old man is all right." The continual changing of help is not conducive to successful operation. Proper management will hold the best men, but how shall this be secured?

First of all, the work of the plant should be definitely divided among the men. Trouble is sure to follow if two or three men are allowed to take a hand at keying up. Let one man attend to that, and hold him responsible. Go over the whole plant and make a list of the routine work: the packing of engines and pumps, the cleaning of the generators, the windows, the brasswork, the care of filters, the CO_2 machine—everything that there is to be done—no matter how trivial. It will be a list whose size will surprise you. Then, go over it and see how many of the tasks are assigned—and how many are not. More surprises are now due. Then, see that every item is definitely assigned to someone—and hold that one responsible. Is it necessary to say that in this way work can be more evenly and justly divided between the men—and that greater efficiency is sure to follow?

There may be times during the day when a steam pressure of 120 pounds is best, and other times when there ought to be 140 or 160. But, to leave this matter to the discretion (or convenience) of the various firemen (as is actually done in some plants) is a palpable folly. Let a standard practice be determined in such matters and hold every man to the line. Do not have one shift oiling the valve gear every hour, another every three hours, and the other—sometimes. Have a standard. There is a receiver pressure (varying, of course, with the load) at which the engines will show best economy. Do not leave each man to his own devices. Have a standard. Of course, these standards need not be too rigid. An intelligent, interested operative should be encouraged to test new ideas or make experiments; but variations from standard practice should be for that purpose and not to suit the whim or indolence of the operative, and tests or experiments should always be followed by records and reports, else their value is lost. So, have standard-practice instructions for the boiler room and engine room, but do not be a slave to the standards.

When you have thus systematized the work, you may be surprised to find how many of the difficulties in the management of men have been eliminated. Petty jealousies caused by one man encroaching on another's "prerogative" will disappear. There will be no more "shouldering" of work upon another. Tale bearing and the disgusting sequels which always result will have no more reason for existence. Each man has his work to do. If it is not done, the fact is self-evident and no one needs to be told.

It seems unnecessary to urge that the working conditions in boiler and engine room be made as pleasant as possible. Yet there are chiefs who need this advice. So long as the office chair is soft and the spittoon handy, the ventilation or lighting of the boiler room troubles such men not at all. Sometimes one is found who seems to imagine that the less comfort the fireman has the better he will attend to business. Experience teaches most of us a different lesson.

Make few rules and have them simple and explicit. Have them typewritten and posted for all to read. See that they are obeyed. How often does a rule become a dead letter almost as soon as it is made. Such proceedings are not merely useless, they are positively harmful. The indifference engendered communicates itself to other matters. If you have not the time or inclination to see that a rule is obeyed, better not make it.

If a man does a thing especially well, tell him so. Occasionally one needs to use discretion in this matter; but because it might spoil a "swelled head" do not withhold praise from the other fellow.

Frown on the tale bearer—or better, sit on him. The "sucker" is usually a poor workman and takes this means to "make good." Remember this, the same fellow who will bring stories to you, will carry stories of you to others. A man crooked enough to be a tale bearer is too crooked to stick to the truth.

Handling men and station management are subjects so vital to the efficient operation of a plant that, although some discussion has appeared in these columns, we would be glad to hear from others. Two heads are better than one and a dozen better still.

Everything from the Central

Sebastian Ziani de Ferranti showed so much foresight and appreciation of the possibilities of electricity in anticipating the use of high voltages and of large direct-connected units that anything which he may say upon that subject is bound to receive a respectful hearing and more than ordinary consideration, however radical and improbable it may appear. In an address delivered as president of the Institution of Electrical Engineers, Mr. Ferranti has just made the proposition that the whole of the coal which we use for heat and power should be converted into electricity. The electricity is to be distributed by mains and utilized for all industrial and domestic purposes in which heat, light or power is required. The smelting of metals in blast furnaces is even to be more economically effected by electric furnaces. The use of the nitrates obtained in the byproduct from the numerous generating stations will result in the intensification of agriculture and contribute largely to an extended and beneficial employment of labor, as well as enabling the country to obtain all its necessary food without the need of importation and at less cost. In this way are realized coal conservation, home-grown food and the better utilization of labor, which are the three desirables pointed out by Mr. Ferranti's paper.

For this general idea to come about it is necessary to have an efficiency of conversion of at least 25 per cent. of the energy of the coal into electrical energy. At present Mr. Ferranti believes that the amount which we get back and use for work of one kind or another is much less than ten per cent. of the energy of the coal. He does not expect that this will be accomplished by the use of internal-combustion engines, and believes the steam gas turbine in which steam is used as a gas at high temperature will, in the course of time, supply the necessary means. A very high load factor will be obtained, Mr. Ferranti says 60 per cent., and machinery of the normal capacity of 25,000,000 kilowatts would have to be installed to produce a supply estimated at 151,400,000,000 kilowatt-hours as a basis upon which the scheme would be commercially profitable in Great Britain. Mr. Ferranti estimates that the scheme he proposes would enable electricity to be supplied throughout the country at the average price of one-eighth of a penny, or one-fourth of a cent per kilowatt-hour, and that it would only be a matter of time for all heating and cooking to be done by that means.

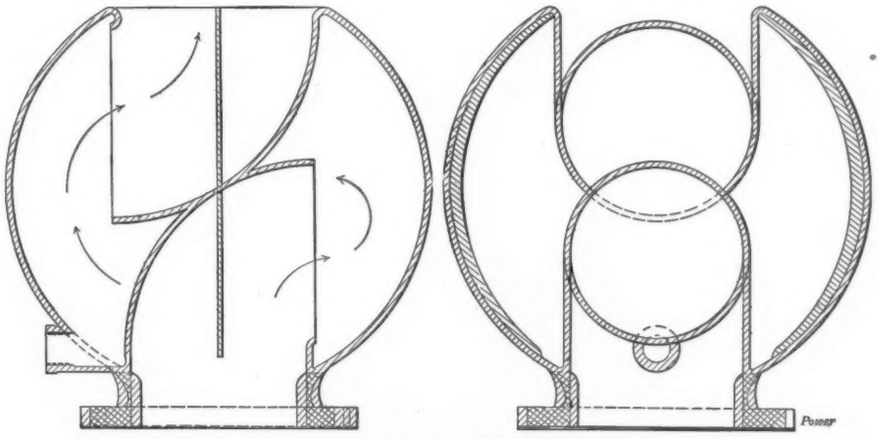
New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news.

The R-K Exhaust Head

This head is made in one solid piece of cast iron, external and internal, and there are, therefore, no internal parts to rust, corrode or become loose.

The illustration shows sectional views of the head, also the three changes in direction of exhaust steam before leaving the head. The steam on entering the head is immediately changed in its direction of travel and then expands into larger volume during the next change of direction and all moisture clinging to the outer surface falls to the bottom of the head and is led off through the drip pipe.



SECTIONAL VIEWS OF "R K" EXHAUST HEAD

The steam is once more changed in its direction of travel and leaves the exhaust head through a larger opening than the inlet of the same at the top.

Sizes up to and including 4 inches are for screwed pipe connections; all sizes above this are flanged.

This exhaust head is manufactured by Walter G. Ruggles Company, 54 High street, Boston, Mass.

Sarco Type "G" Multiple CO_2 Recorder

The Sarco multiple unit CO_2 recorder is designed to make continuous determinations of the CO_2 content in furnace gases and in its several sizes will make separate and simultaneous records from one up to ten boilers.

Furnace gas is led to the CO_2 recorder through individual pipe lines, each of which is connected to a seal *A*, Fig. 1. Each gas line has a ¾-inch sampling tube perforated with holes extending into the last pass of the boiler, and just outside the flue or boiler setting a filter is placed to remove soot from the gas. From the filters, a ⅜-inch pipe is used to conduct the gas to each unit of the recorder, the small diameter being used to reduce time lag, and because no clogging will occur as filtering and draining of moisture are done at the boilers.

Suction is produced by means of the motor-driven suction fan *B*, located at the bottom of the machine. A steady stream of gas is drawn through the seals *A* and internal gas line *C*, which is connected to the seals. The object of the latter is to produce an equal degree of suction for each unit which can be observed, as the seals are made of heavy glass tubing and the gas bubbles through the paraffin oil in the seals, the inlet pipes *D* being perforated. Before passing to each unit, the gas is again filtered at the internal filters *E*, which are cast-iron cylinders containing a brush through which the gas must pass.

The motive power for drawing the gas through each unit is provided by an overhead tank of paraffin oil *G*, located at the top of the machine. The oil is led to the units by the line *H*, and, by virtue of its head, draws samples of gas through the tees located between the seals and internal gas line. The gas passes through inlet lines *J*, Fig. 2, to the measuring or inlet burette *K*.

As the paraffin oil which is being constantly fed to the units gradually fills the pipe lines *L*, it rises in each measuring burette to the inlet connection *M* and prevents further gas being trapped. The oil continuing to rise forces the gas

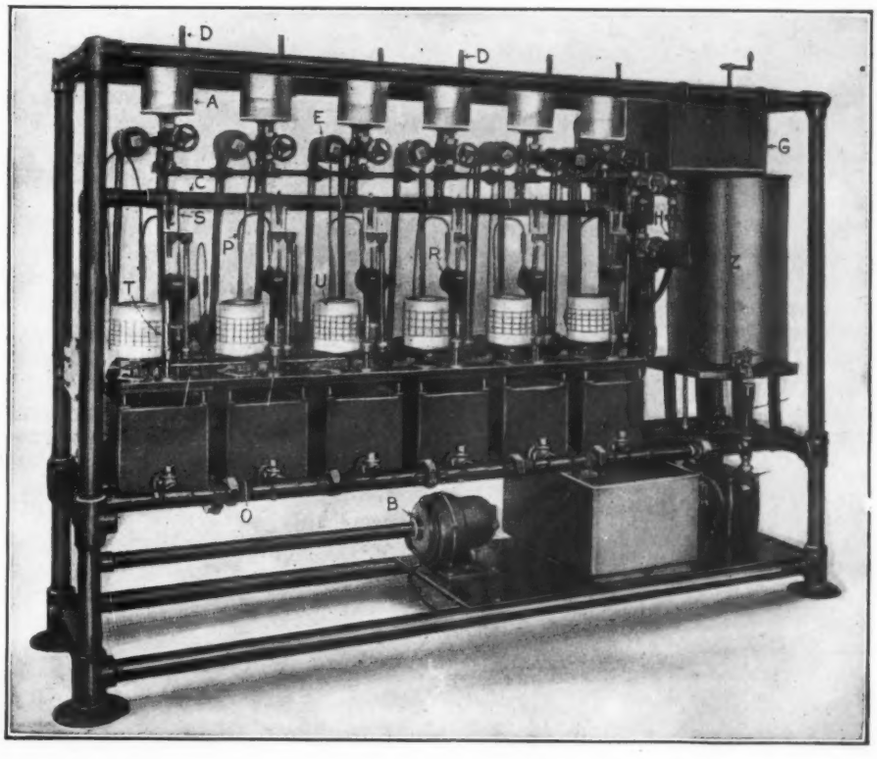


FIG. 1. SARCO MULTIPLE CO_2 RECORDER

through the capillary copper tubes *N* into the bottom of the absorption vessels *O*, Fig. 1, where it is deprived of its CO_2 content by being bubbled through the caustic potash solution contained therein. The remainder of the gas is forced up through the capillary tube *P* into the recording burettes *R*. The latter are also supplied with paraffin oil from the main supply and within each is suspended a metal float (not shown) which is frictionless. The gas, under pressure, forces the paraffin oil out of the burettes and the floats are carried down with the liquid.

Each float is suspended from the frictionless wheels *S* by means of strong threads which also carry the pen *T* for making the record of the CO_2 content in each sample on the charts *U*. While this is being accomplished the paraffin oil is continually rising in the risers *V*, Fig. 2, and central siphon *W*. The hight of the latter is such that as soon as a record is made, the siphon starts to flow and passes all the oil into the discharge tank *X*, where it is simply pumped up into the supply tank by means of the pump *Y*. The supply tank contains a filter to constantly cleanse the paraffin oil, and also has an overflow communicating to the discharge tank.

Caustic potash is placed in the tank *Z*, water added and the whole thoroughly mixed after dissolving. The solution is then fed to each absorption vessel through the line and plug cocks shut and if desired the remaining solution can be run off through valve (27) and the system washed with water to prevent crystallization of the solution which will stick to the inside of the tank and pipe line. When the solution in each vessel is saturated with the CO_2 gas and will absorb no more, the plug cocks are opened and the solution run off as before.

When the siphon starts to flow, the paraffin oil in the system having the pressure reduced recedes from the measuring burettes. The gas which has forced the float downward is then pressed back into the absorption vessel at the top through the tube *P* and leaves the vessel by the exit tube *A'*, whence it reaches the atmosphere by the riser tubes *U*.

The recording charts are mounted on drums which are driven by worm gears on a clock shaft. The latter is driven by a powerful clock. To remove the chart drums it is only necessary to lift them from their base plates. The latter receive their motion from spur gears located on their shank driven by the worms on the clock shaft.

As soon as the siphon has stopped flowing one cycle is completed, the time being about three minutes if 20 records per hour are to be taken. The gas is again drawn through the inlets to each unit and another operation commences. The pen is automatically inked by returning to an ink-well after each record.

As to renewals of solutions— the paraffin oil is never changed; the ink-well has a capacity for a week's run. The caustic solution, if made to about 1.25 specific gravity, will last ten days on 24-hour shifts. The only adjustment necessary is setting the pen to zero when running on air. Everything else, except the winding of the clock, chart and caustic renewals, is automatic.

This CO_2 recorder is manufactured by the Sarco Fuel Saving and Engineering Company, West Street building, New York City.

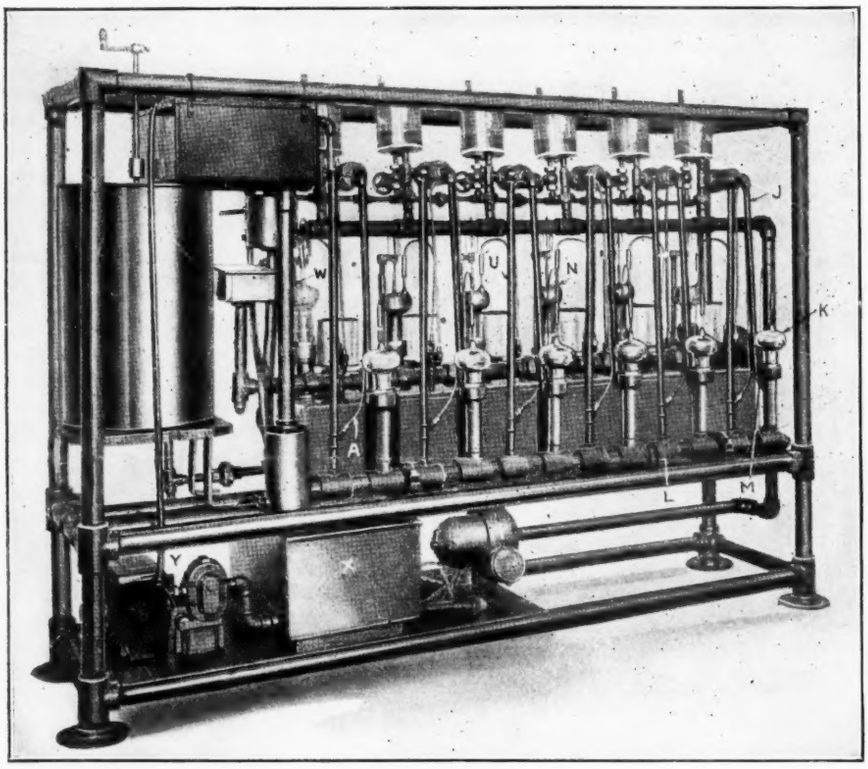
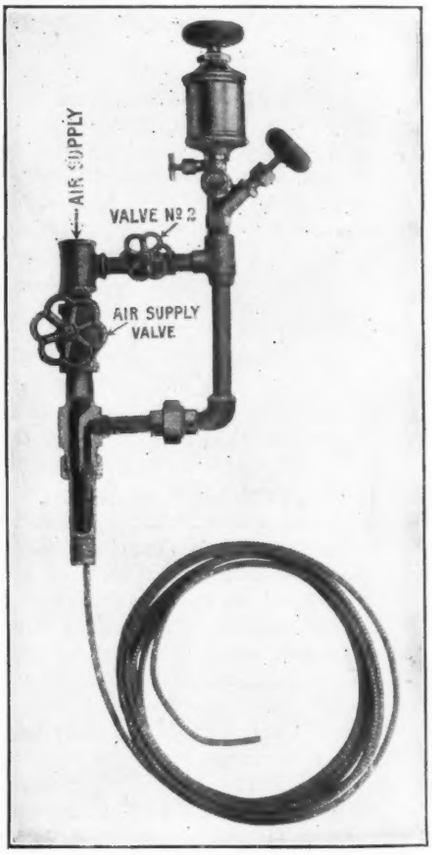


FIG. 2. VIEW OF RECORDER FROM OPPOSITE SIDE

Loganda Automatic Lubricator

It sometimes happens that when exceptionally hard scale is being bored out, the oil in the reservoir of the Lagonda tube cleaner will be exhausted before a tube is finished and the cleaner will run hot before the operator notices it. In order to provide against this difficulty the Lagonda Manufacturing Company, Springfield, O., has brought out a new automatic lubricator shown in the illustration. This lubricator has the advantage that the cleaner does not have to be withdrawn from the tube in order to replenish the oil supply. Furthermore, the sight-feed oil cup and suitable valves make it possible to exactly keep track of the rate of the oil feed and to adjust the supply to the needs of the cleaner.



LUBRICATOR FOR TUBE CLEANER

This lubricator can be attached to the air-supply pipe in any convenient place, and consists of a sight-feed oil cup and two valves. As practically all air tools use flexible rubber hose, it is inadvisable to mix the oil directly with the air and blow it through the entire hose, as oil causes rubber to deteriorate rapidly. The

lubricator is provided with a separate flexible metal hose which conveys the oil directly to the tool and is placed inside of the rubber air hose.

The rate of oil feed can be regulated by the cock at the bottom of the oil cup, then by opening valve No. 2, connected to the air supply, this oil is thoroughly mixed with a small portion of air and blown through the inner tube to the boiler-tube cleaner or other pneumatic tool.

This lubricator can be placed on the wall or any other rigid object, where it will not be in the workmen's way or subject to derangement by the vibrating tool. It is stated that the thorough system of lubrication thus effected will increase the life of the tools by 50 per cent. and will save at least 50 per cent. of the oil, as the rate of feed can always be maintained proportional to the demand of the tool.

National Gas and Gasolene Engine Trades Association

The National Gas and Gasolene Engine Trades Association held its regular annual meeting at Racine, Wis., December 13, 14 and 15. The association has grown constantly from its start, each meeting being larger than the one preceding it, and its affairs are reported as being on a most substantial basis.

The papers presented at this meeting tended in general to the recommendation of more attention to detail on the part of the manufacturers of the various auxiliary devices with the object of raising the standard of reliability of service. In a paper entitled "Gas Engines," Frederick Lammert, of Lammert & Mann, Chicago, made a strong plea for higher-class auxiliary apparatus. Mr. Lammert called attention to the neat, compact, self-contained outfits furnished with automobiles and hoped that some such concentration and improved methods of installing auxiliary apparatus would be developed for the stationary field.

Charles Kratsch, of Colborne Manufacturing Company, Chicago, read a paper along similar lines entitled, "Does the Efficiency of the Gas Engine Depend on its Equipment?" Before giving the obvious and expected affirmative answer, Mr. Kratsch cited the records of his firm, which does an extensive business in placing second-hand gas engines and whose trouble department is unusually well qualified to speak on the subject of gas-engine defects. It was brought out that 29 per cent. of the breakdowns of gas-engine plants within his experience was due to the auxiliary devices. He cited cases where engines costing thousands of dollars had the cheapest of electrical equipment, wiring, etc., all of which is a detriment to the gas-engine business in general.

"Simplicity, the Basis of Reliability," was the title of a paper by J. C. Miller, of Mariner & Hoskins, Chicago. Mr. Miller urged that the strongest possible efforts be made to simplify the equipment in gas-engine plants, as this was really the solution of most of the difficulties experienced with gas engines. It was also pointed out that as the supply of gasolene is steadily decreasing, the question of utilization of kerosene and benzol, a byproduct of coke ovens, be taken up so that when the time comes that gasolene will actually go out of use, the present manufacturer will be ready to meet the question of fuel supply for his engine.

In a paper entitled "Gas Producers," H. F. Smith, of the Smith Gas Power Company, Lexington, O., emphasized the importance of attention to details in the design of producer plants. He said that the fact that a plant was running and had been accepted by the purchaser could not always be taken as evidence of the complete success of the design, and, in fact, the status of the producer power plant as revealed by the inside history of the business was not entirely satisfactory. Troubles with this class of installation were laid largely to lack of attention to details of manufacture and also to the prevailing idea that a producer is nothing more than a modified hard-coal stove. Purchasers have in the past been misled by this claim of simplicity to the great detriment of the business. It was pointed out that in reality there is a vast amount of essential detail in producer design, the subject being just as complex and far-reaching as any other branch of engineering. Installation defects have also been the cause of much dissatisfaction with producer plants, while the minor equipment and the practice of putting 15-cent auxiliaries on $15,000 engines was another frequent cause of failure. Mr. Smith said that in his estimation 60 per cent. of the cases of trouble in producer plants was due to the auxiliaries.

Officers for the coming year were elected as follows: C. O. Hamilton, of Elyria, O., president; O. C. Parker, of Racine, Wis., vice-president; O. M. Knoblock, of South Bend, Ind., treasurer; Albert Stritmatter, of Cincinnati, secretary.

Detroit was chosen as the place of next meeting, which will be held some time in June, 1911.

Profit Sharing and Pension Plan

The directors of the Edison Electric Illuminating Company, of Brooklyn, in recognition of faithful and efficient service and for the encouragement of thrift and investment in the securities of the company on the part of the employees, has authorized a plan of profit-sharing and pensions as an addition to the welfare plans now in operation.

At the end of the year 1910, employees will be credited with a sum out of the profits of the company's operations for that year, in accordance with the following schedule:

To those employees who have been in the company's service two full calendar years, a percentage of their salary or wages for the year 1910, equivalent to one-quarter of the rate of dividends paid on the capital stock during the year; to those employees who have been in the company's service three years, a percentage equivalent to one-half of the rate of dividends; for four years, a percentage equivalent to three-quarters of the rate of dividends, and for five years, or more, a percentage equivalent to the full dividend rate.

This profit-sharing plan is adopted for the current year only, and it will continue from year to year only as the board of directors may adopt it for each year.

OBITUARY

Walter L. Pierce, who for thirty-two years had been connected with the Lidgerwood Manufacturing Company and for twenty-nine years its secretary and general manager, died suddenly of heart failure at his winter home in the Hotel St. Andrews, New York City, in the early hours of Saturday, December 10, 1910. He was a son of John F. Pierce and was born at Dorchester, Mass., on June 8, 1855. His parents survive him and he leaves a widow, Jane Hutchins, an only son, Walter L. S. Pierce, a brother, Charles C. Pierce, and a sister, Mrs. E. W. Jones.

Mr. Pierce's death was entirely unexpected and was a great shock to his family and associates. He had suffered for several years with nervous troubles but by devoting much of his time to out-of-door pursuits he had apparently recovered. He was feeling particularly well when he left his office on the evening preceding his death.

He was known to a wide circle of personal and business associates. He was remarkable as an organizer and so perfect was his work that no detail of the great business which grew up under his hand was neglected during his long absences from his desk while seeking health, and the coherent body which he formed is a monument to the efficiency of his work. Besides his connection with the Lidgerwood Manufacturing Company, he was treasurer of the Hayward Company and of the Gorton-Lidgerwood Company.

His summer home was at Englewood, N. J., where he was a member of the Englewood Country Club. He was also a member of the Apawamis Golf Club,

the Wright Fish and Game Club, of Canada, the Lawyers Club, the Engineers Club, the Machinery Club, in which he was also a director, an associate member of the Naval Architects and Marine Engineers and of the American Society of Mechanical Engineers and a past president of the National Metals Trades Association.

George F. Seward, president of the Fidelity and Casualty Company, died on November 28 at the age of seventy. He was a nephew of William H. Seward, Lincoln's Secretary of War, and spent a number of years in the diplomatic service, first as consul at several cities in the Orient and later as minister to China. During this period of service he very effectively handled several perplexing diplomatic problems.

In 1887 Mr. Seward entered the insurance business, being elected vice-president of the Fidelity and Casualty Company, and five years later succeeded to the presidency of that company. In spite of an active business career he found time to devote to public and social interests and was at one time vice-president of the New York Chamber of Commerce. Among the societies of which he was an active member are the American Geographical Society, the American Academy of Political and Social Science, the American Institute of Civics, the Electro-Chemical Society, the National Municipal League and the Merchants' Association of New York.

Mr. Seward's successor as president of the Fidelity and Casualty Company is Robert J. Hillas, who entered the service of the company in 1876, at the age of sixteen, as office boy and gradually rose to the position of vice-president and secretary about nine years ago.

PERSONAL

Joseph Breslove, formerly of the engineering department of the Westinghouse Machine Company, has joined with A. Setlotter and taken over the business of the Universal Standard Electric Company, 90 Verona street, Brooklyn, N. Y. It is the company's intention to engage in a general mechanical and electrical-engineering and manufacturing business.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

FLUID-ACTUATED MOTOR. John S. Ward, Chicago, Ill. 977,574.

ELASTIC-FLUID TURBINE. Charles W. Dake, Grand Rapids, Mich. 977,601.

GAS ENGINE HAVING AUTOMATIC EXHAUST OPENINGS THEREIN. Andrew Matson, Los Angeles, Cal. 977,667.

GAS ENGINE. Edwin E. Savard and Winfred E. Jones, Rochester, N. Y. 977,752.

EXPLOSIVE ENGINE. Jesse H. Brown, Belding, Mich. 977,779.

INTERNAL COMBUSTION ENGINE. Lysander E. Wright, Newark, N. J. 977,847.

INTERNAL COMBUSTION ENGINE. Joseph Valentin Laviolette, Amsterdam, Netherlands, assignor to Industrieele Maatschappij Trompenburg, Amsterdam, Netherlands (a Limited Company of Netherlands). 977,885.

ROTARY ENGINE. George F. Leiger, South Haven, Mich. 977,888.

TURBINE. Jan Procner, Pabianice, Russia. 977,899.

INTERNAL COMBUSTION ENGINE. Peter Peterson, San Francisco, Cal. 978,058.

ROTARY MOTOR. Henry F. Weinland, Springfield, Ohio, assignor to the Lagonda Manufacturing Company, Springfield, Ohio, a Corporation of Ohio. 978,085.

ROTARY MOTOR. Henry F. Weinland, Springfield, Ohio, assignor to the Lagonda Manufacturing Company, Springfield, Ohio, a Corporation of Ohio. 978,086.

BOILERS, FURNACES AND GAS PRODUCERS

BOILER. Ephraim M. Wilkinson, Oswego, N. Y. 977,915.

STEAM BOILER. Godfrey Engel, Brooklyn, N. Y. 978,009.

STEAM GENERATOR. Sidney John Ross and Harry Schofield, London, England, assignors of one-third to Oliver Prescott Macfarlane, one-third to Sidney J. Ross, and one-third to Harry Schofield, London, England. 978,061.

POWER-PLANT AUXILIARIES AND APPLIANCES

PRESSURE REDUCER. Charles G. Armstrong, Orange, N. J. 977,427.

PACKING FOR PISTON RODS. George F. Royer and Lewis F. Zweibel, Wilkes-Barre, Penn. 977,477.

VALVE. William E. Sloan, Chicago, Ill., assignor to Sloan Valve Company, Chicago, Ill., a Corporation of Illinois. 977,562.

VALVE. William H. Glenn, Hempstead, N. Y. 977,614.

PIPE COUPLING. Campbell P. Higgins, Roselle, N. J., assignor to the Babcock & Wilcox Company, Bayonne, N. J., a Corporation of New Jersey. 977,740.

VALVE. Gordon Land, Seattle, Wash., assignor to United States Flush Tank Company, Inc., Seattle, Wash., a Corporation of Washington. 977,807.

WATER-TUBE STEAM GENERATOR. Achille Bugnon, Paris, France. 977,927.

TRAP. William S. Elliott, Pittsburg, Penn. 977,943.

CALORIMETER. Alfred M. Parks, Philadelphia, Penn. 977,694.

STEAM INJECTOR. Robert Grundy Brooke, Macclesfield, England. 978,000.

CARBURETER. David M. Tilden, Springfield, Mass. 978,076.

TURBINE FOR DRIVING BOILER-TUBE CLEANERS. Henry F. Weinland and Hermon G. Weinland, Springfield, Ohio, assignors to the Lagonda Manufacturing Company, Springfield, Ohio, a Corporation of Ohio. 978,089.

CARBONATING APPARATUS. Charles L. Bastian, Chicago, Ill. 978,103.

ELECTRICAL INVENTIONS AND APPLICATIONS

SYSTEM OF ELECTRIC MOTOR CONTROL. Wilbur H. Thompson, Wilkinsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 977,571.

ELECTRICAL EQUALIZER SYSTEM. William Cooper, Pittsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 977,598.

DYNAMO ELECTRIC MACHINE. John B. Wiard, Lynn, Mass., assignor to General Electric Company, a Corporation of New York. 977,768.

ELECTRICAL SWITCH. William P. Hammond, Passaic, N. J., assignor to William P. Hammond, Theodore A. Hammond and Woolsey A. Shepard, doing business under the firm name of Securo Manufacturing Company, Passaic, N. J. 977,797.

POWER PLANT TOOLS

PIPE WRENCH. Robert O. Dohm, Dane, Wis. 977,788.

PIPE WRENCH. Thomas James Nicholson, Kingston, Ontario, Canada. 977,896.

BOLT HOLDER AND WRENCH. Charles E. Wood, Danville, Ill., assignor of one-half to Orville J. Gunnell, Danville, Ill. 978,100.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., Col. E. D. Meier; sec., Calvin W. Rice, Engineering Societies building, 29 West 39th St., New York. Monthly meetings in New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., Dugald C. Jackson; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff; sec., T. C. Martin, 31 West Thirty-ninth St., New York.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railroad, Cleveland, O. Next meeting to be held September, 1911, in Boston, Mass.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, Oliver building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., Prof. J. D. Hoffman; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., Carl S. Pearse, Denver, Colo.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Cincinnati, Ohio.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, John Cope; sec., J. U. Bunce, Hotel Statler, Buffalo, N. Y. Next annual meeting in Philadelphia, Penn., week commencing Monday, August 7, 1911.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next meeting at Philadelphia, June, 1911.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

INTERNAL COMBUSTION ENGINEERS' ASSOCIATION.

Pres., Arthur J. Frith; sec., Charles Kratsch, 416 W. Indiana St., Chicago. Meetings the second Friday in each month at Fraternity Halls, Chicago.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; acting sec., Charles P. Crowe, Ohio State University, Columbus, Ohio. Next meeting, Youngstown, Ohio, May 18 and 19, 1911.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. N. Lucas; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Omaha, Neb., May, 1911.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., J. G. Hannahan, Chicago, Ill. Next meeting at St. Paul, Minn., September, 1911.

NATIONAL DISTRICT HEATING ASSOCIATION

Pres., G. W. Wright, Baltimore, Md.; sec. and treas., D. L. Gaskill, Greenville, O.